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THE SUSCEPTIBILITY OF JINTACCS MESSAGES TO JAMMING.(U)
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# NAVAL POSTGRADUATE SCHOOL

## Monterey, California



# THESIS

THE SUSCEPTIBILITY OF
JINTACCS MESSAGES
TO JAMMING

by

Steven M. Keller

March 1982

Thesis Advisor: F.R. Richards

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. AD-A115 | 3. RECIPIENT'S CATALOG NUMBER 732 |
| 4. TITLE (and Subtitle) The Susceptibility of JINTACCS Messages to Jamming | | 5. TYPE OF REPORT & PERIOD COVERED Master's Thesis; March 1982 |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) Steven M. Keller | | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940 | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940 | | 12. REPORT DATE March 1982 |
| | | 13. NUMBER OF PAGES 112 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) | | 15. SECURITY CLASS. (of this report) Unclassified |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

JINTACCS messages/formats; Understandability Curves of Written Messages Given Jamming; Continuous and Burst Jamming; Computer Model to Simulate Electronic Jamming; Comparison of JINTACCS Messages to Plain Text Messages Given Jamming

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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# The Susceptibility of JINTACCS Messages to Jamming

by

Steven M. Keller
Captain, United States Air Force
B.S., University of Washington, 1970
M.B.A., University of Utah, 1977

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY
(COMMAND, CONTROL AND COMMUNICATIONS)

from the

NAVAL POSTGRADUATE SCHOOL
March 1982

Author: S. M. Keller

Approved by: H. Mickovich(?)
Thesis Advisor

Kenneth L. Moore
~~Second~~ Second Reader

Michael D. Sovereign
Chairman, C3 Academic Group

D. A. Schrady
Academic Dean

## ABSTRACT

The JINTACCS program was established to insure the interoperability of tactical command and control systems used in joint military operations. One of the standards JINTACCS has developed is a message format to enhance the exchange of written information within the joint task force. This research investigated the susceptibility of the JINTACCS message formats used in air operations to jamming. The susceptibility was measured by comparing the percent of understandability of JINTACCS messages to all plain text non-formatted messages after each had been subjected to equal levels of electronic jamming. Continuous and burst jamming were modeled for this experiment. The experimental results revealed no statistically significant differences in the percent of understandability between the JINTACCS messages and the plain text messages. Curves of understandability were established from the experimental results for different levels of continuous jamming and different levels of burst jamming.

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## ACKNOWLEDGEMENTS

I wish to acknowledge the guidance and assistance of my thesis advisor, Professor Russell Richards, and my second reader, Captain Kenneth Moore, whose time and advise were very much appreciated. I would like to especially thank Captain John Morrison at TAFIG for his assistance, without which I would not have been able to conduct this experiment. I am also indebted to my fellow students at the Naval Postgraduate School, who generously volunteered their time to be subjects for my research. Finally, I would like to thank my wife, Kathy, whose help and advice were appreciated most of all.

# I. BACKGROUND LEADING TO EXPERIMENT

## A. INTRODUCTION

The Joint Interoperability of Tactical Command and Control Systems (JINTACCS) program was established by the Department of Defense in 1971. It is a joint service interface program designed to develop standards and procedures to insure the interoperability and operational effectiveness of those tactical command and control systems used in support of joint and combined ground and amphibious military operations. One of the standards JINTACCS has developed is a message format to enhance the exchange of information within the joint task force. The purpose of this thesis is to evaluate the susceptibility of the JINTACCS message format to two different types of electronic jamming. The evaluation consists of an experiment where JINTACCS formatted messages are compared to plain text non-formatted messages given an equal amount of jamming for each message.

The reasons behind this thesis are as follows. In the tactical battlefield environment our message communications are subject to two specific types of electronic jamming: continuous and burst. With the new JINTACCS message formats, it is important to consider the effects of jamming on the understandability of these messages before the services implement the system. Experiments such as those performed in this research effort can hopefully reveal that, at the

very least, the U.S. services are no worse off using the JINTACCS format with respect to jamming susceptibility. Also these types of experiments may point out weak areas where the effectiveness or understandability of the JINTACCS message format can be improved. In the joint tactical environment, the communication of critical information between force elements directly affects the success or failure of the mission. It is hoped that research such as this will contribute to success in the joint arena.

## B. JINTACCS

### 1. Purpose

The JINTACCS program was established by the Department of Defense with the overall goal of achieving interoperability of tactical command and control systems in joint and combined operations. Interoperability is defined here as the capability of one service to operate with one or more of the other services in order to increase efficiency, mission effectiveness, or combat power. The key to interoperability is compatibility because it is only when all service forces can exchange information in near real time under extreme combat conditions that interoperability is achieved [Ref. 1]. One part of the JINTACCS program is to develop standard message formats that can be used and understood by all services in a joint arena.

## 2. Overview

The JINTACCS program is a continuation and consolidation of previous DOD efforts to achieve interoperability of tactical command and control systems in joint operations. The need for the program was driven by the proliferation of sophisticated weaponry and computers on today's battlefield. Traditionally, combat tasks have been relatively straightforward with manual procedures using people as the medium to achieve interoperability. In the 1960's the use of automation for tactical systems' tasks increased greatly. Today, all services are actively pursuing automation across the tactical equipment spectrum, resulting in the fact that we can no longer rely on manual procedures nor people to provide interoperability [Ref. 2].

Several lessons were learned from our tactical operations in Southeast Asia, the WESTPACNORTH interface program and the Tactical Air Control Systems/Tactical Air Defense Systems (TACS/TADS) interface program. Two lessons were the recognition that after-the-fact system integration is both costly and time consuming. Another lesson was that joint interoperability is especially difficult after a service's automated systems are put into operation. Also, we learned that standardization among the services can solve some of the problems, but joint service support is essential for standardization to be achieved [Ref. 3]. From this experience and these lessons, the JINTACCS program was

established by the Joint Chiefs of Staff (JCS) in 1971 [Ref. 4].

The mission of the JINTACCS program is "to insure that in-service and joint plans are developed to achieve technical compatibility and that tests and demonstrations are conducted to exhibit the compatibility, interoperability and operational effectiveness of those tactical command and control systems used in support of ground and amphibious military operations" [Ref. 5].

The JINTACCS program methodology is a four step process. The first step was the development of the program architecture, including the information to be exchanged between tactical operational facilities. The next step was the development of an engineering implementation plan that specifies the technical standards required to achieve compatibility and interoperability as specified in the program architecture. This includes the message standards and implementation methods that should be used. Because of its size, the JINTACCS effort was divided into five separate functional segments: intelligence, fire support, amphibious operations, operations control, and air operations. A JINTACCS computer library was established where all message elements are categorized. The third step of the program is to develop the test documents, conduct compatibility and interoperability testing, demonstrate operational effectiveness, and document the results. The fourth and final step

of the JINTACCS program will be the publication of approved documents and standard data elements and sets [Ref. 6].

The standards and procedures established by the JINTACCS program are designed to provide a more effective exchange of information within the joint task force. The JINTACCS message formats were developed by operational experts, joint committees and engineers to satisfy the following standards and procedures [Ref. 7]:

a) Message standards must be man and machine readable

b) A Message Element Dictionary must be used to insure information is understood by all players

c) Interface operating procedures will insure the right messages go to the right people at the right time over the right communications

d) Data standards will insure machines and communications work together.

As the new language of battle, JINTACCS messages must be understood by all players in the joint task force environment. Any ambiguities in the meanings of words, phrases, or terms between services must be eliminated to effectively coordinate the use of people, weapons, and resources. The JINTACCS standards and procedures are designed to meet these goals.

## C. JAMPS

### 1. Purpose

The JINTACCS Automated Message Preparation System (JAMPS) is designed to implement the JINTACCS joint message standard after 1985. It is an automated system that will facilitate JINTACCS message preparation by operations personnel and that will provide for a graceful transition to JINTACCS. The JINTACCS Technical Interface Design Plans, Message Element Dictionary, and Catalog of Keyword Data Sets contain over 5,000 pages of JINTACCS message preparation guidance. JAMPS utilizes computer terminals for message preparation that make those 5,000 pages of guidance transparent to the operator. JAMPS provides menu selection for message preparation, automatically formats message fields, provides editing capability, generates standard message headers and trailers, and sends and receives the prepared messages. In short, JAMPS will provide tactical commanders and operators with an automated capability to deal with JINTACCS message standards in a joint tactical environment [Ref. 8].

### 2. Overview

The basis for Air Force support of the JINTACCS program was established by Program Management Directive (PMD) R-S-9057(1)/64779F, 12 April 1979. The PMD directed Tactical Air Command (TAC) to serve as the lead command for JINTACCS Operational Effectiveness Demonstration (OED)

planning and execution and to give due consideration to automated systems [Ref. 9].

An Intelligence OED performed in 1981 demonstrated the difficulty in preparing JINTACCS messages manually. If the messages are difficult to prepare manually, that is, if no automated assistance is available, it was believed that operators would view the JINTACCS standard as unacceptable [Ref. 10]. In addition, the JINTACCS messages are designed to be machine processable as well as human-readable. Without automating JINTACCS, the standard for them to be machine processable cannot be tested [Ref. 11]. For these reasons, the JAMPS requirement was identified.

The JAMPS software was designed to provide many capabilities while remaining flexible for possible future requirements or changes. It was built on a modular concept and uses tables external to the program code to store information on the JINTACCS standard. This allows changes to the JINTACCS standards to be made quickly as no reprogramming is required. The JAMPS software is designed to [Ref. 12]:

a) Prompt operations personnel during message preparation

b) Format message fields and segments in conformance with JINTACCS rules

c) Provide message editing capabilities

d) Generate the standard message header and trailer information

e) Maintain message history files that sequentially store all incoming and outgoing messages

f) Display and provide record copies of incoming and outgoing messages as required.

Because of the above, the JAMPS software should be "user friendly" and should insure that operators generate accurate JINTACCS messages. This should, in turn, enhance the exchange of critical information on the tactical battlefield and therefore improve interoperability.

In addition, the JAMPS software was designed to accommodate a wide range of operator expertise. The software appears totally menu driven to the novice operator and allows the operator to choose from sets of alternatives. Detailed descriptions are provided at each point to "step" the operator through the process. On the other hand, an experienced JAMPS operator can bypass the cumbersome hand-holding modes and complete a message directly and quickly. The experienced operator can still obtain help, if required, at any point. Finally, the JAMPS software includes a developmental toolkit with a thorough and repeatable test of the software, an "instant replay" of any JAMPS session to help identify and correct any unanticipated problems, and a means for obtaining message preparation statistics [Ref. 13].

The hardware for JAMPS is also of modular design. The Phase I version of JAMPS that is now in use at Headquarters TAC relies on a single central processing unit (CPU),

a PDP-11/70, connected to a number of "dumb" terminals, Perkin-Elmer OWL 1200's. This configuration is what was used for the experiment conducted in this research. Phase II requirements for JAMPS are being worked at this time to provide the hardware for post-1985 JINTACCS command and control communications requirements [Ref. 14].

Overall, the present JAMPS provides an automated message preparation/communication capability that is "user friendly" and that makes the JINTACCS message standards transparent to the operators. The design of the system allows quick changes or modifications to the message formats without changing the program code. The Phase I system that is presently installed at Headquarters TAC is a strong first step towards automating command control communications in a tactical environment. It served as a good testbed for this experiment.

## D. ELECTRONIC JAMMING

Electronic jamming of a data communications link can take many forms. The two jamming forms examined in this experiment are continuous and burst jamming. A brief description of each is given below with an explanation of the way each was modeled.

In continuous jamming a constant level signal is transmitted continuously at the same frequency at which the jammed link or net is operating. To be most effective, the type of signal modulation should be the same as the signal

being jammed, although this is not necessary to interfere with the signal. If the modulation of the jamming signal is different from the jammed signal, then the jamming signal acts as additional noise. If the type of signal modulation is known in advance, the jammer can be much more efficient with the same power level by matching this signal modulation. Consider a simplified ground-to-ground communications link as shown in Figure 1.

Let

S1 = Transmitted Carrier Power Signal

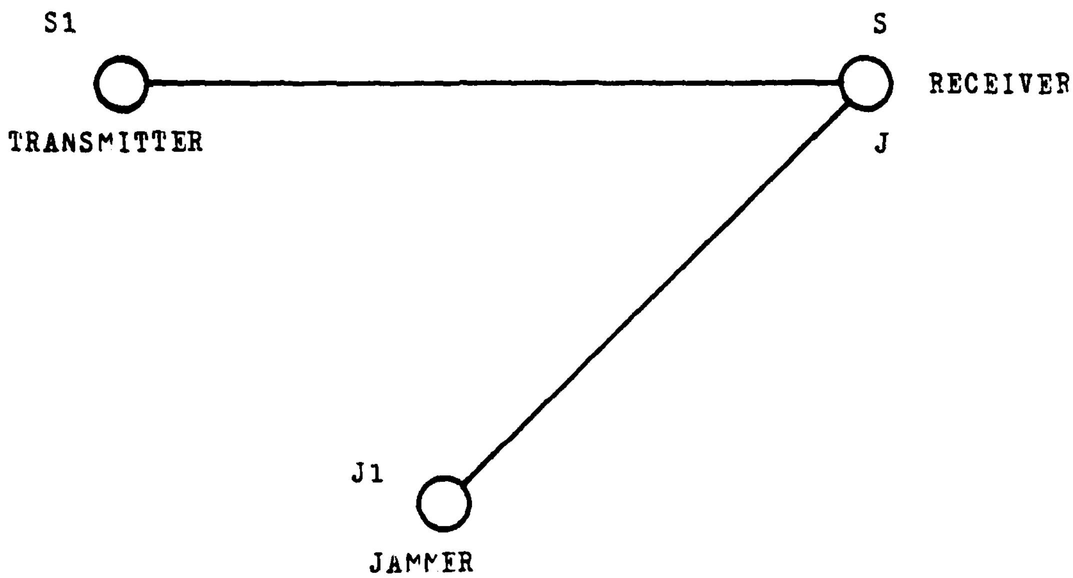
S = Received Carrier Power Signal

J1 = Transmitted Jammer Power Signal

J = Received Jammer Power Signal

From Figure 1, the ratio, J/S, at the receiver determines the effectiveness of the jammer and whether or not it is successful in preventing recovery of the information signal at the receiver. The received power of the jammer, J, and the received power of the transmitter, S, are each determined by the original transmission power, J1 and S1, respectively, the distance of each to the receiver, and the gain of the antennas in use.

The numerical result of the jamming-to-signal ratio, J/S, determines the amount of the information signal that is received correctly and the amount that is garbled. It is assumed that the garbling occurs on a random basis depending on this ratio. When the ratio is known, it can be equated to a probability of jamming on a bit by bit basis. In other




Simplified Ground-To-Ground Communications Link

Figure 1. COMMUNICATIONS JAMMING SCENARIO

words, a specified J/S ratio at a receiver can be transformed into a probability that each information bit is received correctly or incorrectly and hence a probability that any information bit is garbled or jammed.

This probability of jamming (P(J)) is the basis for the continuous jamming portion of the computer model used in this experiment. The computer model reads a message file, translates each character into an eight bit code used in data transmission, and then garbles the bits serially based on a P(J) specified by the user. If the bit is garbled, it is switched from a 1 to a 0 or a 0 to a 1, otherwise the bit is left in its original state. Since the parameters affecting the J/S ratio at the receiver can vary so greatly, the probability of jamming was selected as the primary input for the computer model. Also it was thought that this would be much more useful and more applicable for follow-on applications.

The second type of jamming considered in this research, burst jamming, transmits a jamming signal in bursts instead of continuously. The jamming signal is transmitted for a time interval followed by an interval of no jamming. Like continuous jamming, it is most efficient when the jamming signal's modulation matches the jammed signal's modulation. Burst jamming allows the user to jam two or more signals with the same equipment by splitting his jamming time between each signal. It can, however, be used to jam a single signal.

The parameters of burst jamming are the same as continuous jamming when the burst is "on". There is no effect on the jammed signal when the burst is "off". Therefore, when the burst jammer is "on", its effect on the received signal can also be transformed directly into a probability of jamming, or P(J), and its effect on a serial bit stream can be calculated in the same manner as with the continuous mode.

The probability of jamming along with the time between each burst and the time duration of the burst are parameters used in the computer model to simulate burst jamming. The time between bursts and the time duration of the bursts are each expressed in units of information bits rather than in units of time. Again, due to the great differences in data transmission rates for equipment in the field, i.e. from say 150 bits per second to 9600 bits per second, and burst jamming equipment parameters, it was felt that a computer model that used the number of bits between each burst and the number of bits in each burst would be more useful for varied future applications. Therefore, given a rate of transmission, the burst length in units of time, and the time between bursts, an algebraic transformation can be made to a burst length in bits and time between bursts in bits. These parameters can then be entered into the computer program, along with a probability of jamming during the burst, to simulate the effect of a burst jammer on any given message.

## E. COMPUTER MODEL TO SIMULATE JAMMING

### 1. Background

The computer model simulates jamming a message based on the probability that an information bit will be garbled. As stated in the previous section, the transformation from a jamming-to-signal ratio to a probability of jamming can be made when one assumes that jamming occurs in a random fashion given a certain ratio level. Since information bits are transmitted serially over a data communications channel, the bits will be received serially either garbled or in their original state. The degree to which the received signal matches the transmitted signal depends upon the level of jamming. The higher the level of jamming, the greater the number of information bits that are garbled. A computer program that reads a message at the information bit level in a serial manner was deemed the optimum method to produce a "jammed" message. These "jammed" messages in the JINTACCS format and an all plain text with no format could then be used to perform an understandability experiment.

### 2. Methodology Of Computer Program

The computer model simulates the two different types of electronic jamming selected for this experiment. The computer program is included as Appendix A and is written in FORTRAN. The data file containing the eight bit computer codes for each character are shown in Appendix B. The program was run on a PDP-11/70 in the Command, Control and Communications (C3) Lab at the Naval Postgraduate School.

The program design is as shown in Figure 2. Explanatory comments are provided throughout the program for the reader.

Basically, the computer program reads a message in a data file, translates each character in the message into its eight bit code of 1's and 0's, garbles or jams each bit based on the probability of jamming specified by the user, and then retranslates the garbled bits into whatever characters they have now become. The eight bit code that was used is one parity bit and the seven bit ASCII code. The garbling or jamming of the information bits and hence, characters, is independent of the format of the message that is read into the computer program. The program just reads a file containing characters and spaces, garbles the file at the level according to the program's algorithm, and retranslates the bits back into characters.

The program is written so that the user can specify either continuous or burst jamming. If continuous jamming is selected, the program then asks the user what probability of jamming to use. After P(J) is specified, the program then proceeds to read, garble, and print the "jammed" message. If burst jamming is selected, the program asks the user to specify three parameters: the number of bits between each burst, the length of the burst in bits, and the probability of jamming. After the user inputs his answers, the program again reads, garbles, and prints the "jammed" message. In the burst mode, the program jams the number of bits in the burst, skips the number of bits between

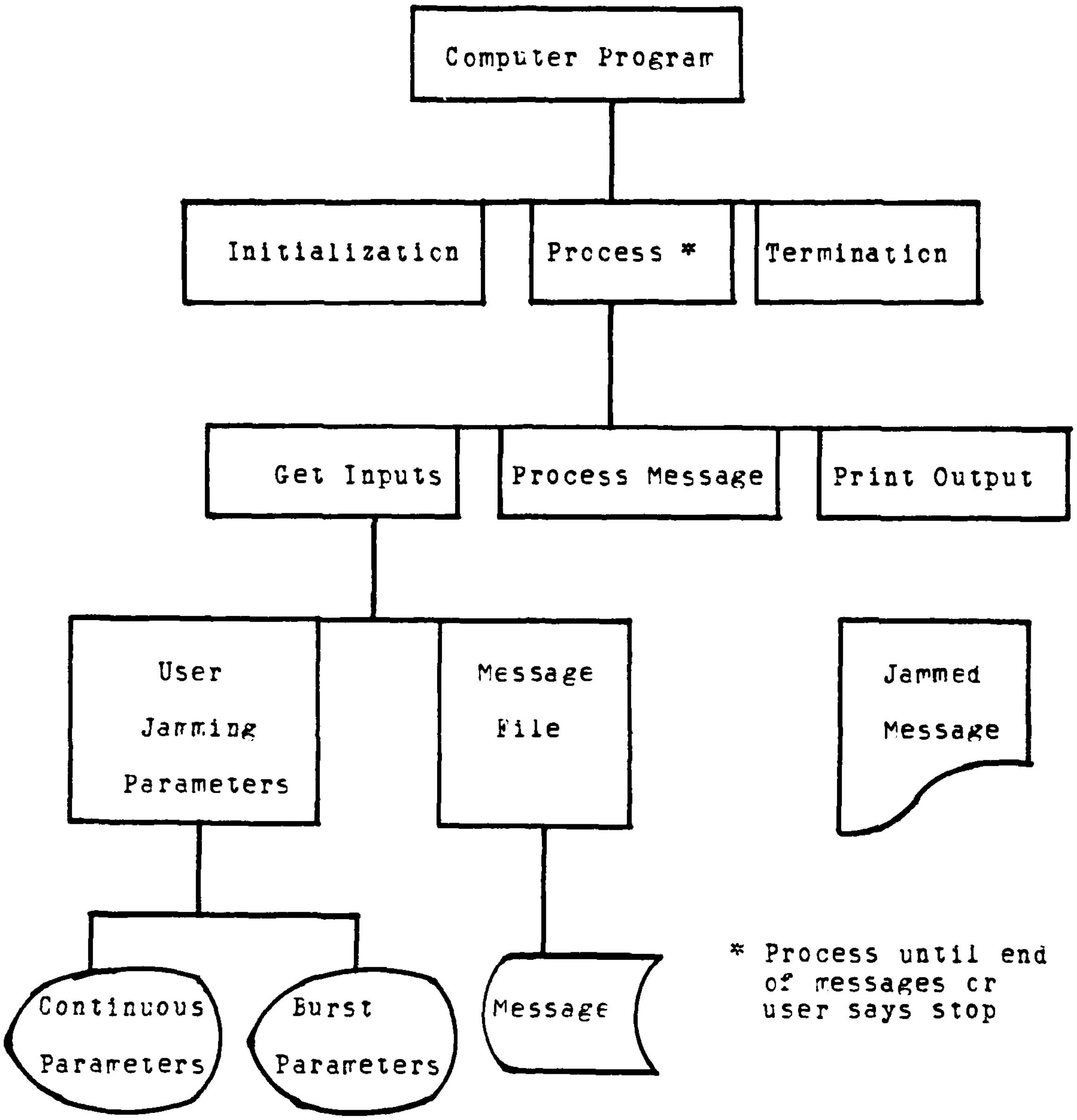



Figure 2. COMPUTER PROGRAM DESIGN

bursts, and then repeats the process. So the bursts can be very far apart or they can be close enough to approach the continuous jamming case.

The program is written so that any number of messages can be processed from a file. The messages must be separated by a '$' in the first column of the line separating the end of one message and the beginning of the next. In this manner, the program will keep reading messages until it reaches the end of the file. There is no special character to denote the end of file; the program stops after the last line of the last message. A sample input showing a file containing two messages, one JINTACCS and one plain text, is shown in Appendix C. A sample output file of these same messages after continuous jamming with $P(J) = 0.01$ (1.0%) is shown in Appendix D. A sample output file using burst jamming with 100 bits between each burst, a 25 bit burst length and $P(J) = 0.10$ (10.0%) is shown in Appendix E. It is then a simple matter to send the output file to a printer to obtain a hard copy of the jammed messages.

3. Artificiality Of The Model

Any simulation model should reflect reality as accurately as possible or feasible. The further the model is from reality or the more limitations the model has, the less credibility it has as a model. As long as the user is aware of a model's limitations, and the limitations are not too severe, the model can still be a very useful tool. The computer model to simulate continuous and burst jamming for

this experiment has four limitations that the reader should be aware of.

The first constraint of the computer model is that carriage returns and line feeds were not allowed to be jammed. The model reads and garbles a line of text after it has determined the last non-space character in the line. It then reads the next line of text, finds the last character in the line, proceeds to garble that line, and the process is repeated until it reaches the end of the message. If the model were to include the carriage return in the jamming process, the model could end up printing one line over another if the carriage return were garbled. If all the carriage returns in a message were garbled, a twenty line message would have all twenty lines printed on the first line of the output file. This over-printing would obviously be useless to try to decipher and it would not matter whether the characters had been garbled or not. This over-printing problem, although it would happen in reality, was therefore not considered useful to include in the model. The purpose of the jamming is to see if one message format is more understandable than another given the same amount of character garbling on each. If all the lines were over-printed, there would be no way to differentiate the two message formats.

The second constraint of the model is the number of characters that were included in the computer program's translation table. The table is shown in Appendix B and

the reader will note that only capital letters were used. This is realistic since the teletype equipment used by the military to process messages uses only capital letters. The limitation is that there are more special characters in the table than are available on a standard tactical military teletype keyboard. With the advent of optical character readers that use the IBM Selectric character set found in many fixed base military communications centers, the character sets are almost the same. However, the fact remains that for the tactical environment in which JINTACCS will be used, the number of characters available is less than that shown in the model. This limitation is considered minor when one considers that once one or more of the bits in a character are garbled, the character is retranslated into whatever character it has now become. It does not really matter which new character is printed. In other words, once a character is translated from its original state, it does not matter what character is now printed because one has no clue as to what the character was. The job of trying to decipher and understand the jammed message is the same regardless of the character set used.

The third limitation is also considered a minor one. The model is written such that after the bits in a character are garbled, it searches the data table to see what character the bits have now become. If it does not find a character match, the model prints a space for that character. The selection of a space for an unknown character was purely an

arbitrary selection. The selection had to be made because it was and is unknown as to what a printer would print if the bits do not match any known character. There is the additional problem of the possibility that the bits might be translated into a control character of some type that affects machine processing or the printer itself. This could have a disastrous effect on a printer if it occurred. The selection of the space character for an unknown character seemed proper, therefore, and this constraint was considered minor in light of the overall need to produce jammed messages for the experiment.

The fourth and final limitation of the computer model is the exclusion of any kind of coding for bit error detection and correction. Coding is one of the techniques available to overcome jamming. It is the addition of one or more extra bits after so many information bits to provide a parity check on the previous information bits. These extra check bits are redundant since they carry no additional information other than the check data. Many modern data communications systems take advantage of bit error correction codes to provide for the automatic identification and correction of any transmission errors introduced into the system. The use of these avoids the need for retransmission of a message since the errors can be detected and corrected at the receiver. Therefore time is saved in communicating a message, and the communications channel is conserved by transmitting each piece of information one time only. Two types of bit error

detection and correction codes that could be used are the Hamming code and the Bose, Claudhuri and Hocquergem or BCH code. If a type of coding had been considered in the model, it would have been able to detect and correct errors introduced by the jamming up to a certain point. Beyond that point, that is, after so many errors had been introduced, the coding would not be able to correct them. For example, using a Hamming (7,4) code, there are 4 information bits and 3 check bits for a total of 7 bits per codeword[Ref. 15]. This Hamming (7,4) code will detect and correct 1 error in the 7 bits, which can be equated to a probability of jamming of 1/7 or about 14.3%. Therefore, this code could overcome up to a 14.3% rate of jamming; beyond that it could do no good. Since the type of coding in use varies, the level or amount of jamming each code could overcome can be calculated fairly easily and the appropriate level of jamming can then be selected for the model. For these reasons, a bit error detection and correction code was not selected nor used in the computer model.

## F. SUMMARY

The purpose of this thesis is to investigate the susceptibility of the JINTACCS message format to electronic jamming. The investigation consists of an experiment that compares the understandability of the JINTACCS message format to a plain text message format given equal amounts of jamming to each. The need for this research arises from the fact that the

JINTACCS message standards are in the development stage and are due for implementation by all services in 1985. In addition, electronic jamming of our tactical data communications is more of a possibility in today's world. It is therefore critical to know that these new JINTACCS message formats are at least as effective in communicating information in a jamming environment as a plain text non-formatted message. In the joint tactical environment, communicating and understanding critical information between force elements directly affects mission success. We need to verify that we are not adversely affecting our capability to succeed.

The object of this research is to provide a realistic test of the understandability of one type of JINTACCS message format applicable to Air Force operations. It is hoped that this research effort will provide valuable information to both Air Force and other service decision makers that would otherwise not be available.

## II. DESCRIPTION OF THE EXPERIMENT

### A. OBJECTIVES AND CONSTRAINTS

The object of this experiment is to compare the effectiveness of the JINTACCS message format to a plain text message format in an environment subjected to a certain amount of jamming. Effectiveness is measured as a subjective rating of the degree of understandability of those pieces of critical information contained in each message. The critical information in one message format may not be in the same field or fields as in another message format so that the effectiveness rating considers the entire message. Specifically, the experiment was designed to determine if there was any significant difference in understandability between JINTACCS formatted messages and plain text non-formatted messages after each had been subjected to equal levels of two types of jamming.

The experiment was constrained by the facilities available to the Tactical Air Forces Interoperability Group (TAFIG) at Langley AFB, Virginia, and the C3 Laboratory at the Naval Postgraduate School (NPS).

### B. SUBJECTS

Two groups of subjects were used for the experiment. A pilot trial was conducted at NPS using student volunteers. The main experiment was conducted at Langley AFB with a

second group of military subjects on a temporary duty training to use JINTACCS.

The pilot trial group consisted of 16 military officers representing the Air Force (9), Army (4), and Navy (3). The officers included 15 males and 1 female. Their grades ranged from Captain to Major and Lieutenant to Lieutenant Commander. The subjects' ages ranged from 29 to 39 with an average age of 33. Their length of service varied from 6 years to 14 years with an average length of military service of 9.5 years. All of the subjects in the pilot trial were enrolled in the Command, Control and Communications Curricula at NPS. Their backgrounds were quite varied including communications, missile combat crew commander, computers, weapons control, electronic warfare, navigation, artillery, infantry, surface warfare, and naval flight.

The second group of subjects at Langley AFB consisted of 25 military officers representing the Air Force (18), Navy (2), Marines (1), Air National Guard (3), and Air Force Reserves (1). There were 24 males and 1 female. Their grades ranged from 2nd Lieutenant to Lieutenant Colonel and Lieutenant to Lieutenant Commander. The subjects' ages ranged from 24 to 44 with an average age of 31 years old. Their length of service varied from 2 years to 22 years with an average of 11 years of military service. The backgrounds of the subjects in the second group also varied widely.

The second group of subjects were on temporary duty (TDY) at Langley AFB to receive JAMPS training and to then participate in an Air Operations Interoperability Test of the JINTACCS message standards. The subjects' experience in their operational facility ranged from no experience to six years and no exercise participation to approximately 20 exercises. Only a handful of the subjects had JAMPS training prior to this experiment, so the majority were seeing JAMPS for the first time and were in the initial training mode.

## C. EQUIPMENT

### 1. JAMPS Terminal

The computer system at Langley AFB that was used for this experiment consisted of numerous terminals connected to a Digital Equipment Corporation (DEC) PDP-11/70 computer. The computer terminals were Perkin-Elmer Owl 1200's, which are the standard view screen and keyboard terminals common today. Their display is a 12-inch diagonal inverse video (white-on-black or black-on-white) cathode ray tube (CRT) [Ref. 17]. The keyboard is fixed-alphanumeric with 16 (shiftable to 32) functional control keys and 6 additional function keys collocated with alphanumeric keys [Ref. 18]. The terminal can display 24 lines with 80 characters per line.

The keyboard of the JAMPS terminal is divided into two basic groups, alphanumeric keys and function keys. The alphanumeric keys are used by the JAMPS operators to create

and enter the data for any or all fields of a JINTACCS-formatted message [Ref. 19]. They are like those keys on a standard typewriter keyboard. The function keys are used for editing, verification and transmission of the various JINTACCS-formatted messages [Ref. 20]. These keys are color coded and dual action, requiring upper and lower case operation.

2. JAMPS Operation

The operation of the JAMPS terminal is fairly straightforward. After the operator is logged on, he simply types 'JAMPS' to initiate the JAMPS program. A menu showing a category selection list appears on the display and the operator can choose the type of action he wants to accomplish (see Figure 3). The operator can choose one of six different types of message formats, messages that have been saved, a transmitted message file, a received message file, or he can quit.

If the operator chooses one of the six types of JINTACCS messages, he is then presented with a submenu display of all the available messages within the desired category. An example of a partial submenu display for Air Operations messages is shown in Figure 4.

From this submenu, the operator chooses the message number of the desired message, and the blank message template is displayed. An example of the blank message template for number A650 or Apportionment/Allotment Message

```
ADMIN --- U N C L A S S I F I E D        00ADMI ADMIN---

 1    ADMIN
 2    AIR OPERATIONS
 3    CPS CONTROL
 4    INTEL
 5    FIRE SUPPORT
 6    AMPHIB
 7    Messages Saved
 8    Messages Transmitted
 9    Messages Received
10    *** Quit ***
```

Figure 3. JAMPS CATEGORY SELECTION MENU DISPLAY

AIROPS --- U N C L A S S I F I E D          00AIRO AIROPS--

| MSG-NO | MESSAGE TITLE |
| --- | --- |
| F541 | Acknowledge Message [AKNLDG] |
| E710 | Air Defense Command Message [ARDEFCOM] |
| E715 | Air Defense Warning Message [AIRDEFWARN] |
| A651 | Air Employment/Allocation Plan [EMPLOYALOC] |
| A661 | Air Mission Request Status/Tasking Message [REQSTSTSK] |
| B704 | Airbase Change Report [ABCHANGE] |
| F631 | Airlift Mission Schedule [ALMSNSCD] |
| D630 | Airlift Request [ALREQ] |
| B705 | Alert Aircraft/SAM Status Report [ACSAMSTAT] |
| A772 | Alert Launch Order [ALORD] |
| A650 | Apportionment/Allotment Message [APORALOT] |
| F654 | Cross-Force Mission Data Confirmation Message [CROSSCONF] |
| A653 | Cross-Force Mission Data Message [CROSSDAT] |
| F750 | Designated Area Message [DESIGAREA] |
| F751 | ECM Data Message [ECMDAT] |
| B711 | Engagement Status [ENGSTS] |
| F632 | Flight Control Information Message [FLTCONTINFO] |

Figure 4. JAMPS AIR OPERATIONS SUBMENU (Not Complete)

(APORALOT), which is an air operations message format, is shown in Figure 5.

The operator can then compose and type his message. He can fill in the blanks in the format shell or "mask" mode or he can select either a "help" mode or a "conversation" mode which will assist him in filling in the complete message. The mask mode is designed for the more experienced JAMPS operator. The help mode allows the experienced operator to review the meaning of a single field or the type of data to be entered in that field. The operator can jump back and forth between the mask and help modes. The conversational mode is designed to provide detailed instruction to the novice user by guiding the operator through the message in a field-by-field manner [Ref. 21].

## D. MESSAGES USED FOR THE EXPERIMENT

As stated previously, there are six categories of JINTACCS messages. These are administrative, air operations, operations control, intelligence, fire support, and amphibious. Since the test subjects were at Langley AFB for an Air Operations Interoperability Test, the air operations messages were chosen for this experiment. An alphabetical list of the JINTACCS air operations messages as of 30 July 1981 is shown in Appendix F [Ref. 22]. For the experiment, the following air operations messages were used: acknowledge message, airlift request, search and rescue incident report, airbase change report, message change report, sortie allotment

```
A650G01A xxxxxxxxxxxxx                     00A650 A650G01A

FROM/PLA: ______________ /RI: _______

/ADDR: ____________________________________________ /CLASS: __

/PRIPREC: _ /SECPREC: _ /DTG: ______________//

TO/PLA: ______________ /RI:_______

/ADDR: _______________________________________________ //

INFO/PLA: ______________ /RI: _______

/ADDR: _______________________________________________ //

CLASS/CLAS: UNCLAS

/DESIGNATOR: ________________________________//

SIC/SID-CODE: ___ //

EXER/EXERCISE: ____________________________________________

/EXER-ADD: ________________ //

OPER/OPERATION NAME: ______________________________

/OPLNNO: ______________________ /OPT-NICKNAME: _____________

/SEC-OPT-NICKNAME: ________________________ //

MSGID/MSG-TITLE: APORALOT            /MSG-ORIG: ___________

/MSG-SER-NUM: _______ /MNTHNM: ___ /QLF: ___ /SERNUM: ___ //

REF/MSG-TITLE: ____________________ /MSG-ORIG: ______________

/DATE-TIME-REF: _______ /MNTHNM: ___/MSG-SER-NUM: _____ /SIC: ___

/SPEC-NOT: ________ //
```

Figure 5. JINTACCS APPORTIONMENT/ALLOTMENT (APORALOT) BLANK MESSAGE TEMPLATE DISPLAY

message, alert aircraft/SAM status report, cross force mission data message, request confirmation message, flight control information, and request status task message.

The messages used for the experiment were made up with the same information in each format. For example, an airlift request message was made up using the proper JINTACCS message format. It is shown in Figure 6. The same information was then rewritten in a plain text or plain English message, as shown in Figure 7. In this manner, each message contained exactly the same critical information but was packaged differently. Specific questions could be asked of a test subject to determine the amount of critical information the subject could extract, given equal levels of garbling to each message type.

## E. EXPERIMENTAL PROCEDURE

### 1. Conduct Of The Experiment

The experiments were conducted in two phases; pilot trials at NPS and main experiment trials at Langley AFB. The procedures used for each are described separately below.

For the pilot trials, the subjects were given individual message packets to complete. Each packet contained five plain text messages that had been garbled at different levels of continuous and burst jamming. No JINTACCS messages were included in these pilot trial packets since the subjects had received no JINTACCS training nor was any JINTACCS material available for their use. Each packet was arranged

```
FROM/ABCC1/RUJIAAB/ABCCC LANGLEY AFB VA/U/O/O/152055Z OCT 81//
TO/JTF-JTB1/RUJICAD/JTF JTB FT MONMOUTH NJ//
TO AF-TACC1/RUJIAAB/AF TACC LANGLEY AFB VA//
UNCLAS
OPER/PTU CERTIFICATION//
MSGID/ALREQ/ABCC1/1015001//
CANX/ALREQ/ABCC1/141200Z/OCT/1014001//
AMPN/AMENDMENT 3//
LIFTREQ/-/REQNO:5G107/PRY:1/TALTYP:AIRLD/NOTPAC:5C130//
6LOAD
/DE ONLOC   ONTIME    QTY  LDTYP  - -   OFFLOC OFFTIME  QTY
/01 UDTHAN 161300Z  245   PASSENGERS   KORTAB 161400Z  230
/02 UDTHAN 161300Z   40  AMMO CRATES KORTAB 161400Z   40
//
9LOAD
/DE CARGOWT CARGOSZ LGTH WDTH HEIGHT  HZD SD NEW    CC
/02   10TON  30CUF  3FT  2FT  5FT     A - N  -  1TON//
LANDPT/UDTHAN/PTNM:UDORN AIR BASE:261030N1073530E//
CONTACT/UDTHAN/-/CNTNAME:CAPT MORRISCN/8048502072/LSSTAT:COLD
/TWO RAMPS.//
HEADING/SPECIAL INSTRUCTIONS//
AMPN/CONTACT BOOMER ON FREQ 245.5 PRIOR TO LANDING AT UDTHAN.//
AKNLDG/N//
RMKS/CODE 6 PASSENGER REQUIRES TLC AT DESTINATION.//
```

Figure 6. SAMPLE JINTACCS AIRLIFT REQUEST MESSAGE

```
ROUTINE
ZNR UUUCC
R 212237Z OCT 81
FROM ABCC1  LANGLEY AFB VA//
TO  RUJICAD/JTF-JTB1  FT MONMOUTH NJ//
RUJIAAB/AF-TACC1  LANGLEY AFB VA//
BT
UNCLAS
OPERATION: PTU CERTIFICATION
THIS IS THE FIRST ALREQ SENT OUT BY OUR UNIT TODAY. THIS MESSAGE CANCELS OUR
ALREQ #1, AMENDMENT 3, SENT YESTERDAY.  THIS MESSAGE REQUESTS AIRLIFT
(REQUEST NUMBER 5G107, PRIORITY: 2) USING FIVE C-130 AIRCRAFT.  THE AIRCRAFT
WILL ONLOAD 245 PASSENGERS AT UDTHAN AT 1300Z TOMORROW.  CARGO WILL ALSO BE
ONLOADED AT THE SAME POINT (10 TONS, 30 CUBIC FEET, WITH A LENGTH OF THREE
FEET, WIDTH OF TWO FEET, AND HEIGHT OF FIVE FEET).  THE CARGO IS AMMUNITION
(HAZARD TYPE "A").  "SINGLE DAGGER" IS NOT REQUIRED. THE NET EXPLOSIVE WEIGHT
OF THE AMMO IS 1 TON.  PASSENGERS AND CARGO WILL BE TRANSPORTED TO KORTAB, TO
ARRIVE AT 1400Z ON THE SAME DAY.  PASSENGERS AND CARGO WILL THEN BE OFFLOADED
AT KORTAB.  THE C-130'S MUST CONTACT BOOMER ON FREQUENCY 245.5, PRIOR TO
LANDING AT UDTHAN (261030N  1073630E).  NO ENEMY ACTIVITY HAS BEEN NOTED AT
UDTHAN.  SPECIAL EQUIPMENT NEEDED AT UDTHAN INCLUDES TWO RAMPS.
PHONE CAPT MORRISON (804-850-2072) ON ARRIVAL AT UDTHAN.  THE MESSAGE YOU
SEND SHOULD INCLUDE THE FOLLOWING SPECIAL INSTRUCTIONS:  "CODE 6 PASSENGER
REQUIRES TLC AT DESTINATION."
BT
```

Figure 7.  SAMPLE PLAIN TEXT AIRLIFT REQUEST MESSAGE

so that it contained five sets of garbled messages and questionnaires on the critical pieces of information. The questionnaire for a message immediately followed each message. The questionnaire had from 6 to 19 short answer fill-in-the-blank questions. The questions were worded to minimize the possibility of leading the subject or helping him deduce the answer from the garbled message or from the other questions. A sample questionnaire used for the airlift request message is shown in Figure 8.

The subjects were given instruction sheets stapled to the front of the packet. They were told that the reason for conducting this experiment was to determine the understandability of these messages at various levels of jamming. Their responses would be examined to estimate how message understandability is affected by jamming. They did not know how much jamming each message had been subjected to, nor did they know which type of jamming had been used on any message. The instruction sheet explained that the messages in the packet had been garbled by a computer model that simulates electronic jamming. The sheet instructed them to do two things. First they were to read the message and correct any garbled letters as best they could by writing the correct letters above the bad ones. It was felt that by correcting the garbled letters, they would be forced to work more to decipher the garbled message and understand it. Secondly, the subjects were instructed to answer the questions concerning each message to the best of their ability.

1. WHAT TYPE OF MESSAGE IS THIS? ____________________________

2. WHAT IS THE FIRST ACTION CITED BY THIS MESSAGE? __________

3. HOW MANY AIRCRAFT ARE REQUESTED? _________________________

4. WHAT KIND OF AIRCRAFT ARE REQUESTED? _____________________

5. WHERE WILL THE AIRCRAFT BE ONLOADED? _____________________

6. WHAT KIND OF CARGO IS BEING ONLOADED? ____________________

7. WHAT IS THE HAZARD TYPE OF THE CARGO BEING ONLOADED? _____

8. IS "SINGLE DAGGER" REQUIRED? _______ YES _______ NO

9. WHERE WILL THE AIRCRAFT BE OFFLOADED? ____________________

12. WHAT FREQUENCY IS TO BE USED PRIOR TO LANDING? __________

11. WHAT SPECIAL EQUIPMENT IS REQUIRED? _____________________

Figure 8. SAMPLE QUESTIONNAIRE FOR AIRLIFT REQUEST MESSAGE

The intent of the pilot trials was to determine the amounts of continuous and burst jamming that should be used for the main experiment. If too little jamming were used, it was felt that no difference in understandability would result. Likewise if too much jamming were used, both message types would be so garbled that neither would be understandable and again there would be no difference between JINTACCS and plain text messages. If any difference in understandability between the two message types exists, it was believed that the difference would be most noticeable at that point just before all understandability decreases rapidly. It was hypothesized that a plot of understandability versus the amount of jamming would result in curves like those in Figure 9 for continuous and burst jamming. The amount of jamming used for the main experiments should therefore be in the vicinity of the asterisks marked on the two plots.

The experimental procedure was essentially the same for the main experiment at Langley AFB with the second group of subjects. They were told that the experiment was being conducted to determine if there was any significant difference in understandability between JINTACCS messages and messages that were written in plain text given an equal amount of garbling or jamming to each. Each subject was given a packet containing six JINTACCS messages and six plain text messages and each group of six messages was labeled. The subjects were instructed to correct the garbled letters as best they

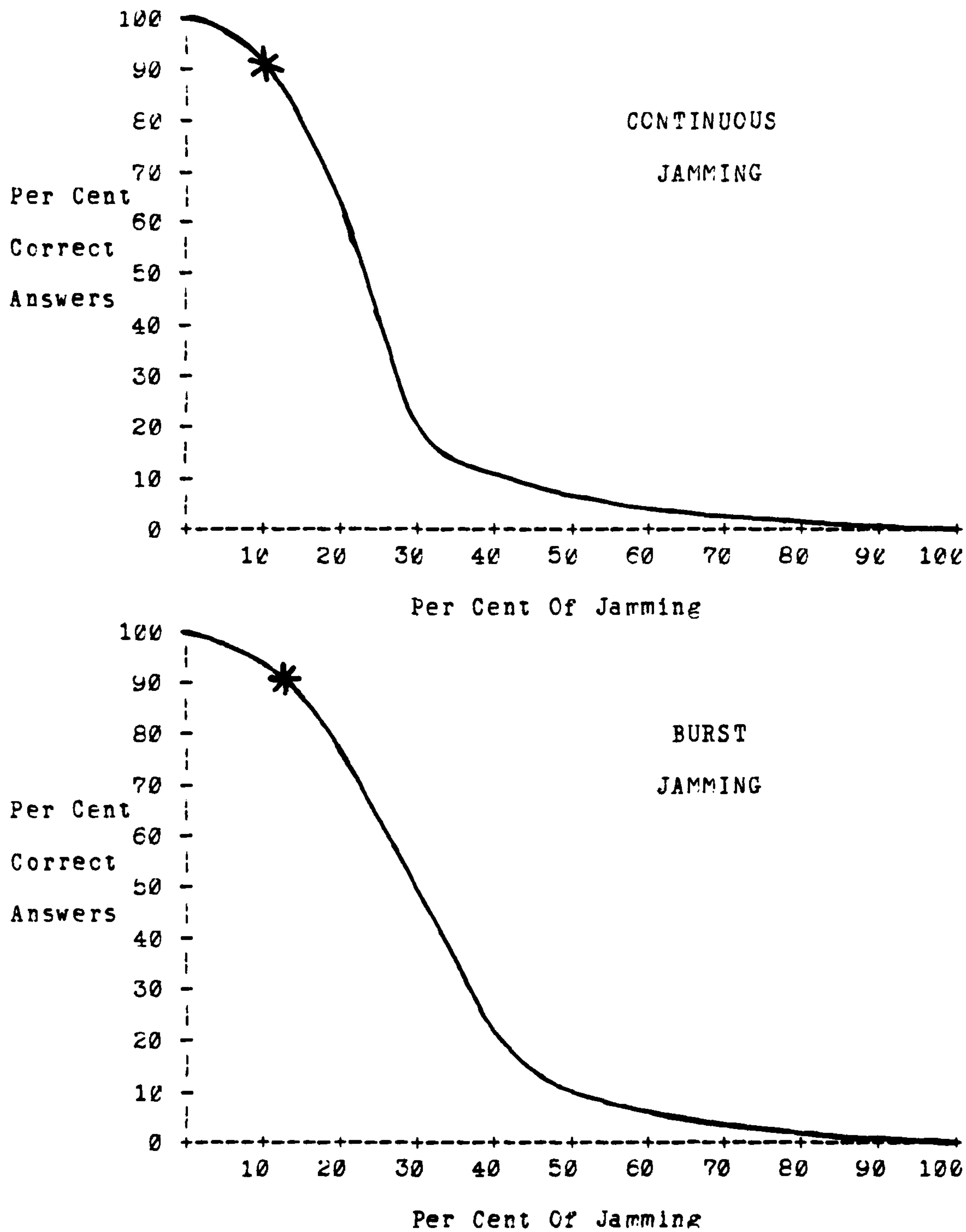



Figure 9. HYPOTHESIZED CONTINUOUS AND BURST JAMMING CURVES

could by writing the correct letters above the bad ones for each message and to answer the questions for each message to the best of their ability. The instruction sheet is shown in Appendix G.

The subjects at Langley AFB were allowed to use the JAMPS computer terminals to aid in deciphering the JINTACCS group of messages in their packet. In this manner, if they could determine what type of message they were working on, they could select that format on the JAMPS terminal and have the blank format displayed. With the display they then knew what type of information was supposed to be in each field. This should enhance their ability to decipher the JINTACCS messages. When working on the plain text messages, the subjects had no computer aids to help in deciphering the garbled messages. The amount of jamming used in the main experiment was determined from the pilot trials at NPS.

The subjects were given a time limit to add some realism to their tasks. They were allowed 60 minutes per message group or an average of 10 minutes per message. The time pressure, although artificial, was an attempt to provide a surrogate for the pressure a subject might encounter in a tactically deployed battlefield environment. However, since it was important for the subjects to finish the messages, and since they were not being tested for speed, the subjects who were not done in 60 minutes were allowed to finish. They did not know in advance that they would be given extra

time to finish. Only a few took longer than the alloted time.

2. Experiment Description

The overall experiment can be divided into basically three separate sub-experiments. The first sub-experiment was conducted at NPS and there were two trials, called the pilot trials. Pilot trial 1 used plain text messages with continuous jamming at 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%, 3.5%, 4.0%, 4.5% and 5.0% (the values represent the probability of garbling an individual bit). Pilot trial 2 used plain text messages with two types of burst jamming at the 1.0%, 3.0%, 5.0%, 7.0%, 10.0% and 20.0% levels.

The second sub-experiment was conducted at Langley AFB and there were three trials. Trail 1 was the control group; each subject had JINTACCS and plain text messages with no jamming. These trials were used to determine if there were differences in understandability due to the type of format even if no jamming were applied. Trial 2 was the test of JINTACCS versus plain text at the 1.0% level of continuous jamming, at the 5.0% level of burst jamming with 100 bits between bursts and 25 bits in the burst, and at the 5.0% level of burst jamming with 200 bits between bursts and 50 bits in the burst. Trial 3 was conducted to estimate the understandability curves for JINTACCS messages. It tested continuous jamming from the 0.5% to 3.0% levels, burst jamming with 100 bits between bursts, 25 bits in the

burst, and from 3.0% to 20.0% levels of jamming, and burst jamming with 200 bits between bursts, 50 bits in the burst, and from 3.0% to 20.0% levels of jamming.

The third sub-experiment was also conducted at Langley AFB and was essentially a follow-up test for the second sub-experiment. There were two reasons for this third sub-experiment. First, the majority of test subjects had received minimal training (one and a half days) before the second sub-experiment. Any differences between JINTACCS and the plain text messages might not be directly attributable to the differences in formats and could be of questionable validity because of the limited training. Secondly, the third sub-experiment enabled us to estimate the understandability curves for both JINTACCS and plain text from the same test group. The first sub-experiment provided estimates of the understandability curves for plain text messages; the second sub-experiment was used to estimate the JINTACCS understandability curves. However, there was no information that would enable us to directly compare the message formats because the groups were different.

There were no control group trials in the third sub-experiment. Trial 2 was repeated but with the addition of continuous jamming at the 2.0% level. Trial 2 therefore provided comparison tests for two types of continuous jamming and two types of burst jamming. Trial 3 was a replication of trial 3 in the second sub-experiment, but both JINTACCS and plain text messages were used.

## F. SUBJECT QUESTIONNAIRE

An 11 item subjective questionnaire was given to each experimental subject at Langley AFB after the subject had completed his message packet. The purpose of the questionnaire was to determine the subjects' attitudes about the JINTACCS message format. The questionnaire is shown in Appendix H and is annotated with the average response to each question from each sub-experiment. The direction of the shift from the first to the second sub-experiments is annotated with arrows, → or ← .

## G. DEPENDENT VARIABLES

The measure, % understandability, was estimated for each trial as follows:

$$\% \text{ Understandability} = \frac{\sum_{i=1}^{N} TC_i}{\sum_{i=1}^{N} TQ_i} \times 100$$

where TC = Total Questions Answered Correctly Per Subject Response

TQ = Total Questions Per Subject Response

N = Total Number of Subjects

## H. HYPOTHESES

The following null hypotheses regarding understandability were tested:

### 1. Hypotheses Regarding Understandability (All Sample Results)

For each category of continuous and burst jamming:

(a) Ho: There is no difference in the percent of understandability between JINTACCS and plain text messages given continuous jamming at the 1.0% and 2.0% levels.

(b) Ho: There is no difference in the percent of understandability between JINTACCS and plain text messages given burst jamming at the 5.0%, 7.5% and 10.0% levels.

(c) Ho: There is no difference in the percent of understandability between JINTACCS and plain text messages given no jamming.

### 2. Hypotheses Regarding Understandability (Middle Results Only)

After the initial analysis of the data, the plain text scores seemed to be grouped closer together while the JINTACCS scores had a greater dispersion with some scores which seemed to be outliers on the low side. In order to determine if the effect of the few outliers was sufficient to alter the conclusions of the statistical tests the upper and lower scores were trimmed from the data sets and the tests were repeated using only the middle 50.0% of the scores. Therefore, to determine if there is a difference in percent of understandability when the top and bottom scores are discarded, the

following hypothesis tests were conducted for each category of continuous and burst jamming.

(a) Ho: There is no difference in the percent of understandability between JINTACCS and plain text messages given continuous jamming at the 1.0% and 2.0% levels.

(b) Ho: There is no difference in the percent of understandability between JINTACCS and plain text messages given burst jamming at the 5.0%, 7.5% and 10.0% levels.

## I. EXPERIMENTAL DESIGN

The experiment was designed as shown in Figure 10. The message packets were made up to include two groups of six messages each. The subjects were divided so that one half would start on the JINTACCS message group while the other half started on the plain text message group. This would insure neither message type received favorable treatment by being first or second all the time. Each subject received the same 12 messages, but the messages were presented in a randomized order. Each of the 12 messages was distinct with its own information. In addition, no subject saw a JINTACCS message and then saw that same message in a plain text format in his packet. The messages were balanced so they appeared in the different packets the same approximate number of times in the JINTACCS and plain text formats. As a result of the above, no two packets were exactly alike. While the subjects

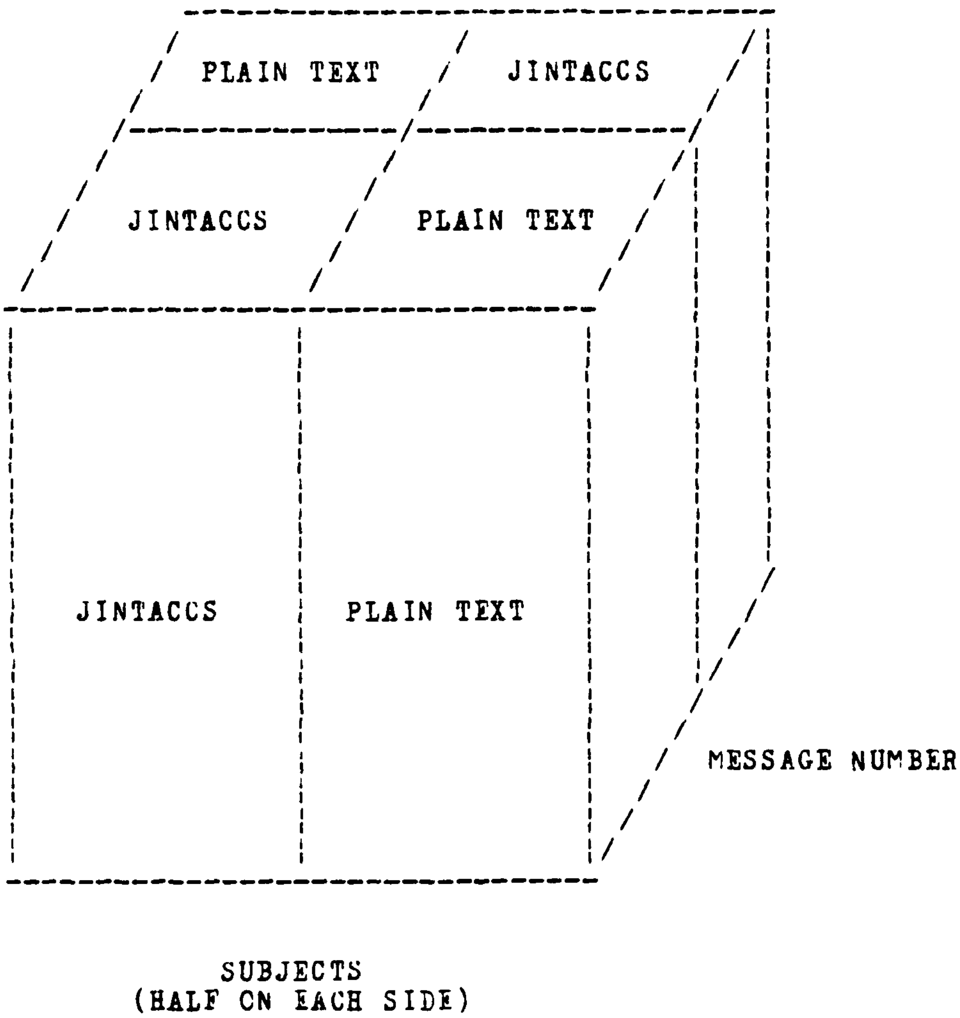



Figure 10. CONCEPTUAL EXPERIMENTAL DESIGN

sat next to each other using the JAMPS terminals for the JINTACCS messages, each subject worked on different messages.

## J. RESULTS

The experimental results for the understandability of JINTACCS and plain text messages are presented in this section. The hypothesis tests for each type of jamming were done by comparing the two sample proportions. The test statistic is [Ref. 23]:

$$z = (p_1 - p_2)/\sigma_p$$

where $p_1$ = Plain Text Proportion

$p_2$ = JINTACCS Proportion

and $$\sigma_p = \sqrt{\bar{p} \cdot (1 - \bar{p}) \cdot \frac{(n_1 + n_2)}{n_1 \cdot n_2}}$$

where $n_1$ = Number of Plain Text Samples

$n_2$ = Number of JINTACCS Samples

$$\bar{p} = \frac{n_1 \cdot p_1 + n_2 \cdot p_2}{n_1 + n_2}$$

Using a significance level of $\alpha = 0.10$, the test would fail to reject the null hypothesis if $-1.645 < z < 1.645$ and would reject the null hypothesis if the z value fell outside this interval.

### 1. Results For Understandability (All Sample Results)

The experimental results for the percent of understandability of JINTACCS and plain text messages using all of the sample results for the first hypothesis tests are

shown in Table I. Both sub-experiments failed to reject the hypothesis in every case, implying no significant difference in understandability exists for the two formats. Because it appeared from the understandability curves at the various levels of jamming that the plain text scores consistently dominated the JINTACCS scores, a Mann-Whitney U test was conducted to do a rank comparison of the results [Ref. 24]. This is one of the more powerful nonparametric tests and is used to determine whether two independent groups have been drawn from the same population [Ref. 25]. It is a most useful alternative to the parametric t test but it does not require any of the t test's assumptions about the populations' distributions nor their variances [Ref. 26]. The test statistic is based on the rank order from the lowest to the highest scores and it might give different results from the proportion test if the one set of scores consistently outrank the others, even though their averages may be close together. The result for this test also failed to reject the null hypothesis that there was no difference in understandability between JINTACCS and plain text messages, except for the continuous 1.0% case from sub-experiment 2 trial 2.

2. Results For Understandability (Middle Results Only)

The experimental results for the percent of understandability of JINTACCS and plain text messages using only the middle 50% of the sample results for the second hypothesis tests are shown in Table II. These tests were run to see if perhaps there is a difference when the upper and

TABLE I

RESULTS FOR UNDERSTANDABILITY (ALL RESULTS)

| Type Of Jamming | JINTACCS | Plain Text | Z Value |
|---|---|---|---|
| **Sub-Experiment 2 Trial 1** | | | |
| No Jamming (Control Group) | 95.83% | 96.57% | 0.12(NS) |
| **Sub-Experiment 2 Trial 2** | | | |
| Continuous 1.0% | 69.2% | 79.4% | 0.95(NS) |
| Burst 100 25 5.0% | 76.9% | 82.8% | 0.42(NS) |
| Burst 200 50 5.0% | 69.6% | 83.9% | 0.97(NS) |
| **Sub-Experiment 3 Trial 2** | | | |
| Continuous 1.0% | 81.42% | 81.45% | 0.002(NS) |
| Continuous 2.0% | 55.63% | 69.12% | 0.74(NS) |
| Burst 100 25 7.5% | 77.27% | 80.8% | 0.22(NS) |
| Burst 200 50 10.0% | 70.34% | 70.0% | -0.02(NS) |

NS = Not Significant

TABLE II

RESULTS FOR UNDERSTANDABILITY (MIDDLE RESULTS)

| Type Of Jamming | JINTACCS | Plain Text | Z Value |
|---|---|---|---|
| Sub-Experiment 2 Trial 2 | | | |
| Continuous 1.0% | | | |
| Upper 25% | 93.9% | 95.6% | |
| Middle 50% | 72.5% | 81.1% | 0.59(NS) |
| Lower 25% | 48.0% | 59.5% | |
| Burst 100 25 5.0% | | | |
| Upper 25% | 90.9% | 100.0% | |
| Middle 50% | 79.1% | 82.3% | 0.17(NS) |
| Lower 25% | 58.8% | 68.8% | |
| Burst 200 50 5.0% | | | |
| Upper 25% | 93.8% | 100.0% | |
| Middle 50% | 71.4% | 81.7% | 0.50(NS) |
| Lower 25% | 35.7% | 70.0% | |

NS = Not Significant

(CONTINUED ON NEXT PAGE)

TABLE II (CONTINUED)

RESULTS FOR UNDERSTANDABILITY (MIDDLE RESULTS)

| Type Of Jamming | JINTACCS | Plain Text | Z Value |
|---|---|---|---|
| Sub-Experiment 3 Trial 2 | | | |
| Continuous 1.0% | | | |
| Upper 25% | 95.7% | 93.1% | |
| Middle 50% | 81.5% | 83.6% | 0.10(NS) |
| Lower 25% | 68.0% | 67.7% | |
| Continuous 2.0% | | | |
| Upper 25% | 87.5% | 90.5% | |
| Middle 50% | 55.8% | 69.7% | 0.58(NS) |
| Lower 25% | 21.7% | 50.0% | |
| Burst 100 25 7.5% | | | |
| Upper 25% | 91.9% | 96.9% | |
| Middle 50% | 76.7% | 83.3% | 0.31(NS) |
| Lower 25% | 62.9% | 60.6% | |
| Burst 200 50 10.0% | | | |
| Upper 25% | 86.4% | 91.3% | |
| Middle 50% | 70.3% | 69.6% | -0.03(NS) |
| Lower 25% | 54.5% | 53.6% | |

NS = Not Significant

lower scores are discarded. Again both sub-experiments failed to reject the hypothesis in every case, implying no significant difference in understandability exists for the two formats.

### 3. Results For Continuous Jamming (JINTACCS Versus Plain Text)

Although the plots of percentage of understandability versus jamming percentage generally follow the hypothesized continuous jamming curve shown in Figure 9, there are some features of the curves unexpected by the experiment. A plot of the percent of correct answers versus the amount of continuous jamming is shown in Figure 11. The plain text results are from the pilot trials at NPS and the JINTACCS results are from sub-experiment 2 at Langley AFB. A plot of their differences at each level of jamming is shown in Figure 12. As can be seen from these plots, the plain text scores were higher at almost all levels of jamming. However, since the results for plain text were from a different group of test subjects than the JINTACCS results, no firm conclusions can be drawn.

The plot of the results from sub-experiment 3, where all responses are from the same test subjects, showed even more intriguing results. The plot of the two curves is shown in Figure 13 and the plot of the difference curve is shown in Figure 14. As the reader can see from these plots, the plain text results were more understandable with light jamming but, at higher levels of jamming (>1.5%), JINTACCS messages were more understandable. A possible reason for

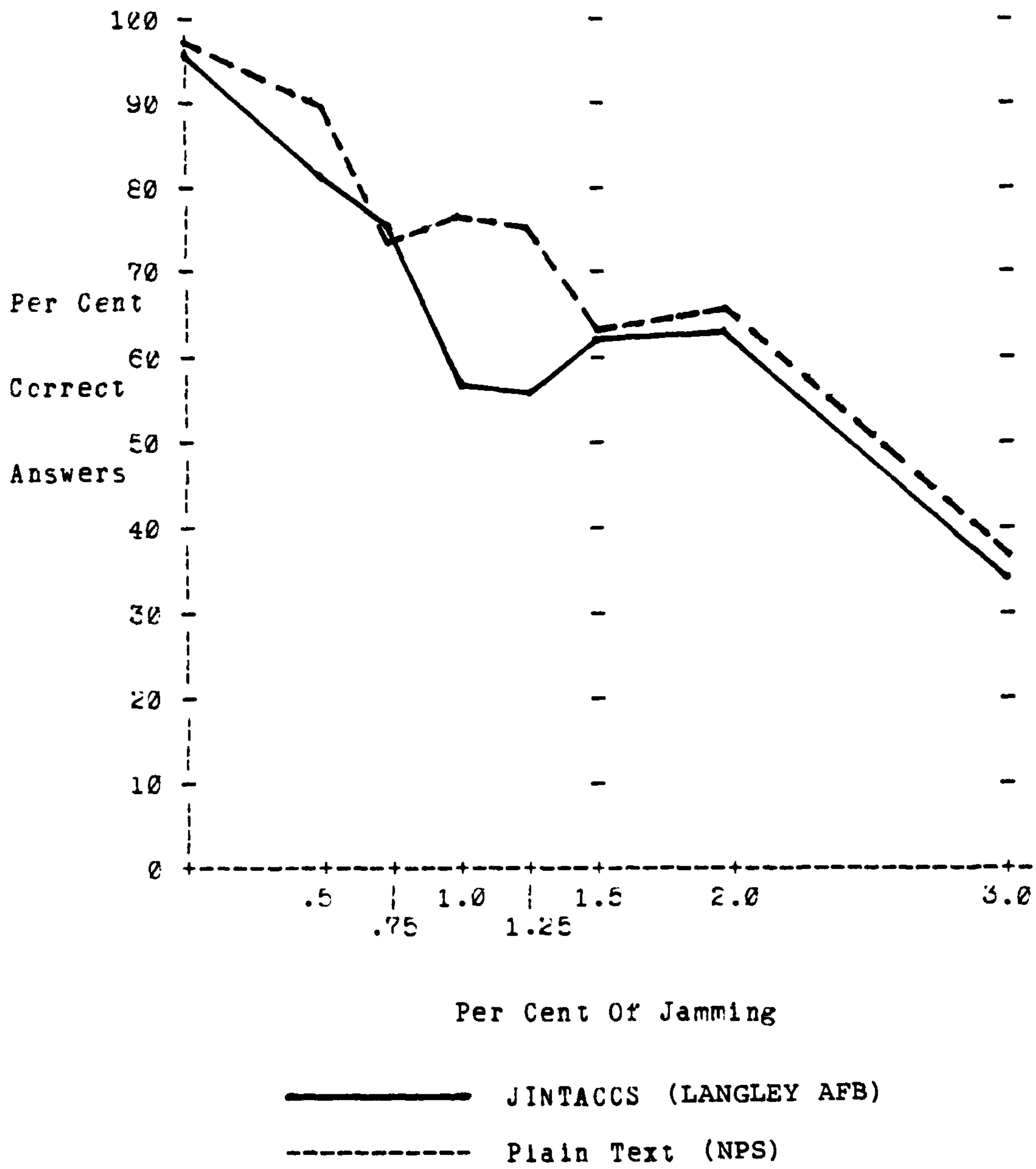



Figure 11. PLOT OF CONTINUOUS JAMMING RESULTS (FIRST PART)

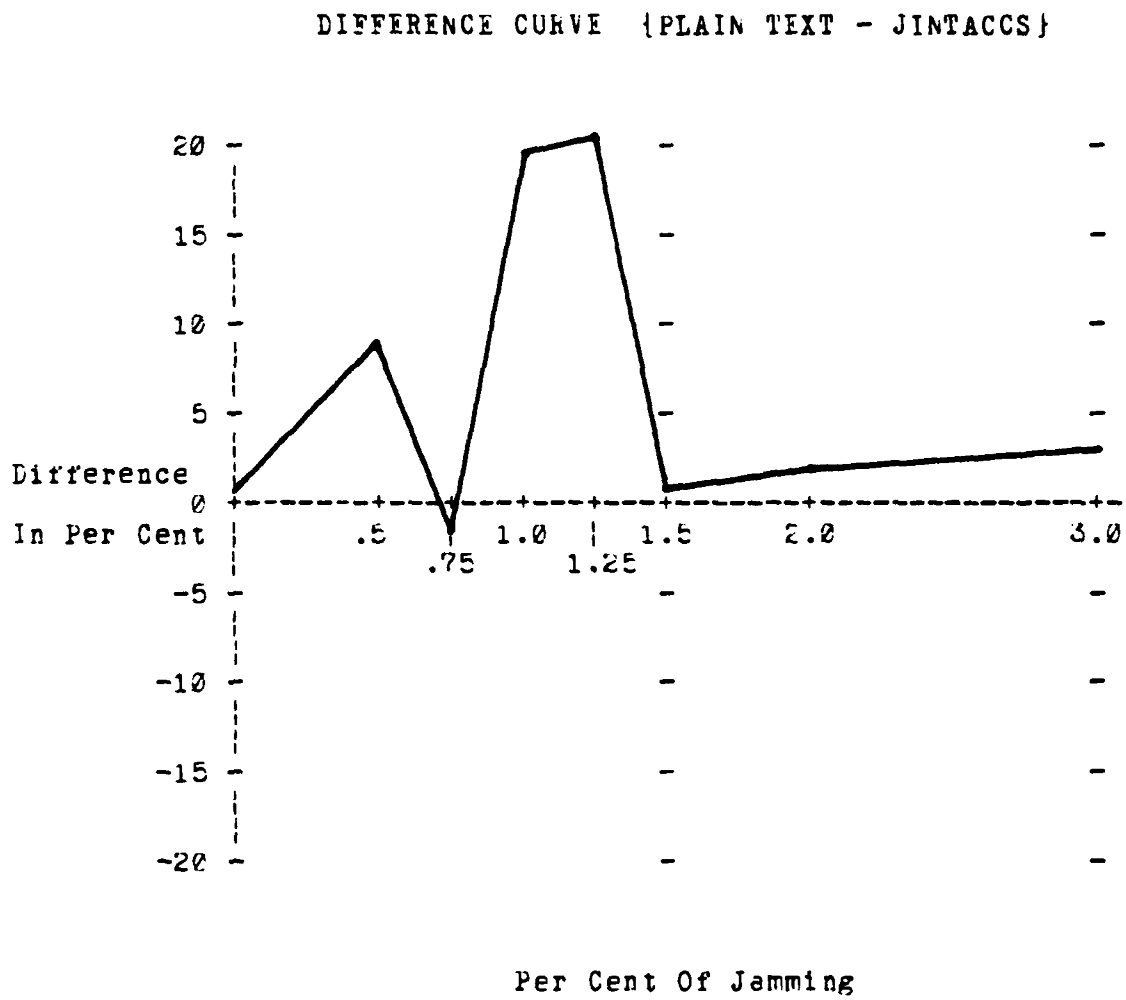



Figure 12. PLOT OF CONTINUOUS DIFFERENCE CURVE (FIRST PART)

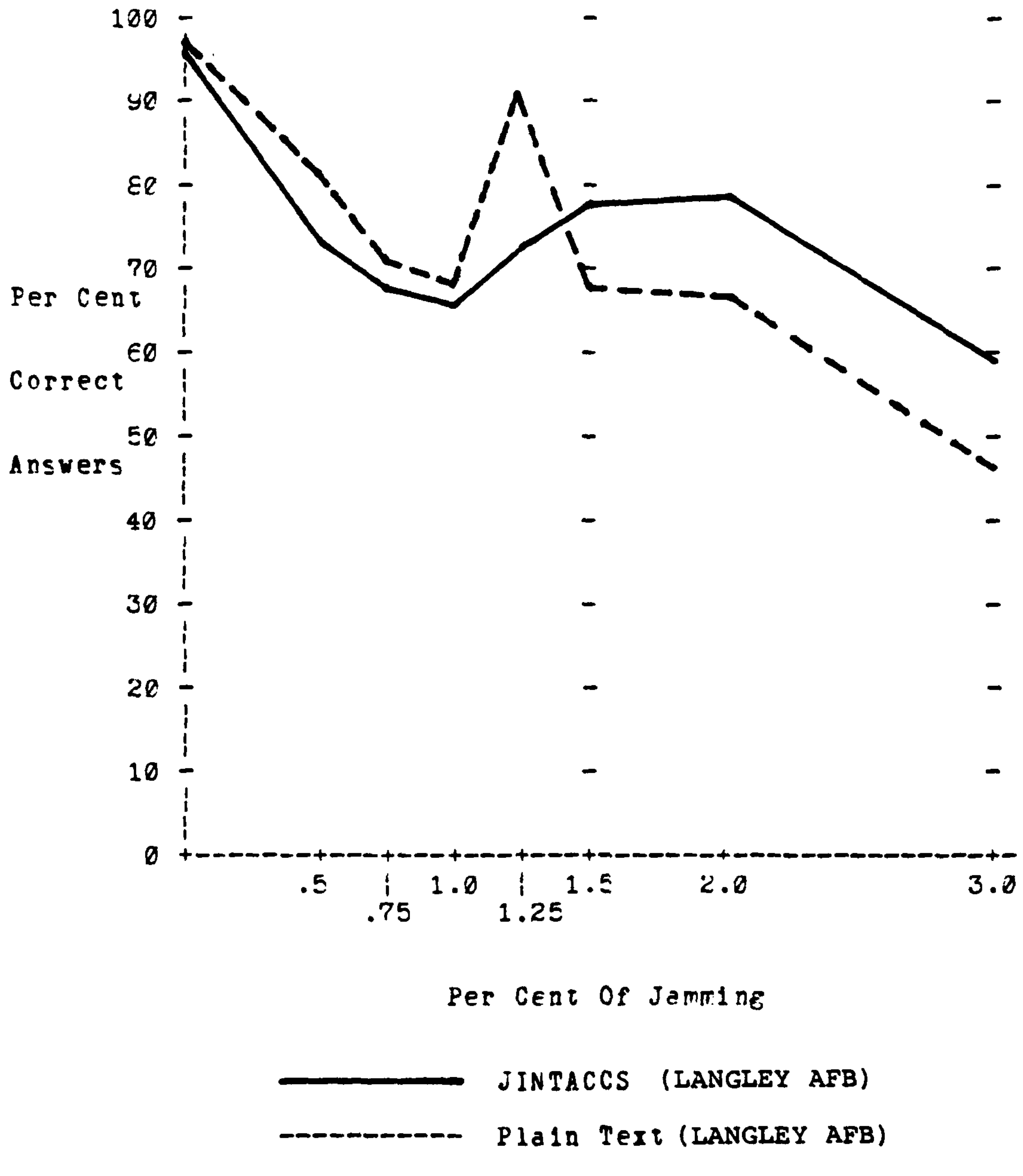



Figure 13. PLOT OF CONTINUOUS JAMMING RESULTS (SECOND PART)

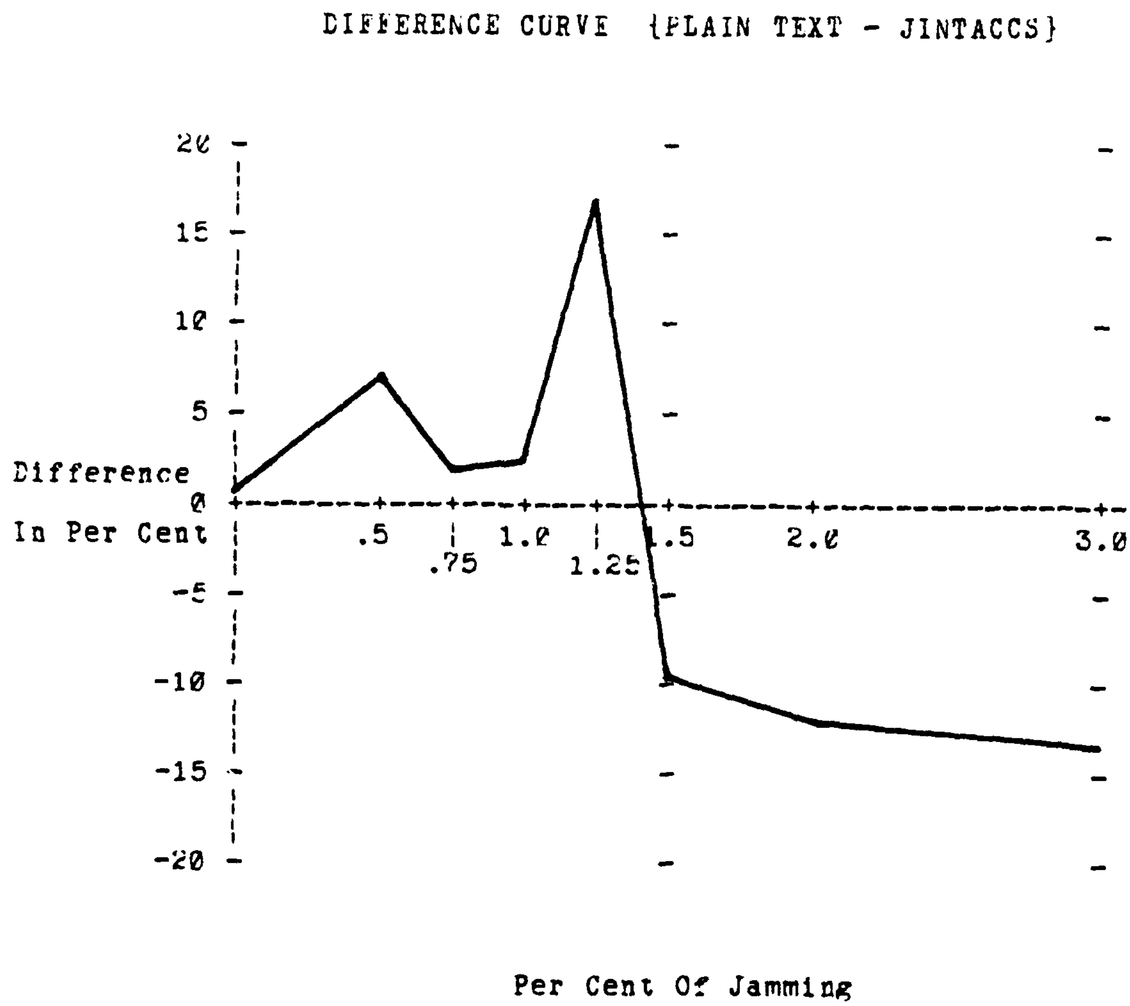



Figure 14. PLOT OF CONTINUOUS DIFFERENCE CURVE (SECOND PART)

this change from the earlier experiment is the amount of training the subjects had received. By the time of the third sub-experiment, the subjects had received a significant amount of training since the second sub-experiment. The additional training and familiarity with the JINTACCS format and the JAMPS computer terminals and the JINTACCS format itself might account for their ability to recover more information given an increased amount of jamming.

A plot of all four results on the same graph is shown in Figure 15 for the reader's review.

4. Results For Burst Jamming (JINTACCS Versus Plain Text)

The results for the burst jamming mode in sub-experiment 1 (the pilot trials at NPS) are shown in Figure 16. The parameters selected for the burst jamming are shown in the figure. As can be seen from the figure, the resulting curves are relatively flat, implying that within the range of values selected for the burst parameters, understandability was not very sensitive to the percentage of jamming. As a consequence, different parameters were chosen for the main experiment. The burst results for sub-experiment 2 are shown in Figure 17. As can be seen from these plots, the results are again fairly level. The results for the burst jamming trials in sub-experiment 3 are shown in Figure 18. A plot of the two difference curves is shown in Figure 19. As can be seen from these figures, the curves have a steeper slope than the pilot trial results in Figure 16, looking

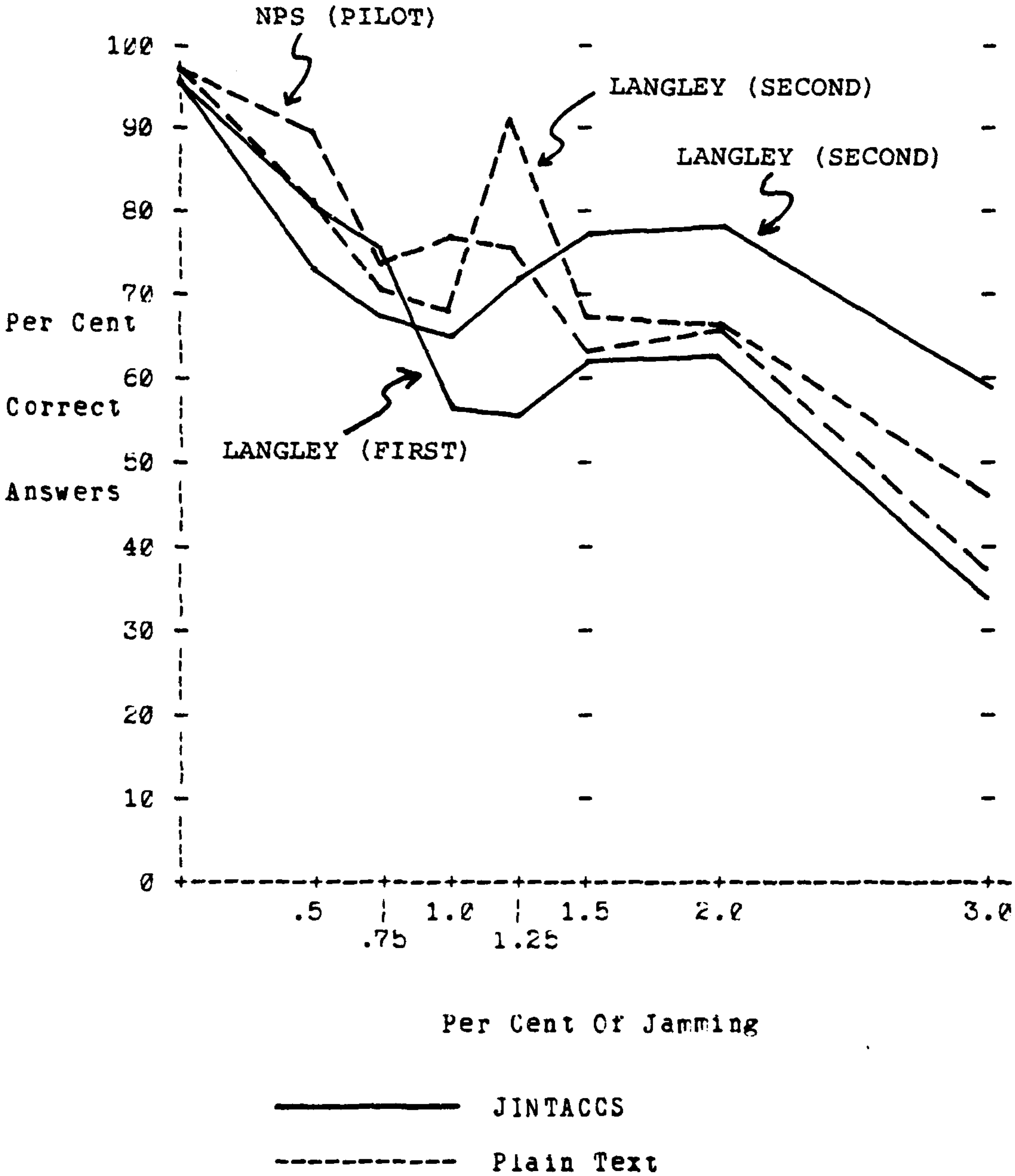



Figure 15. PLOT OF CONTINUOUS JAMMING RESULTS (ALL)

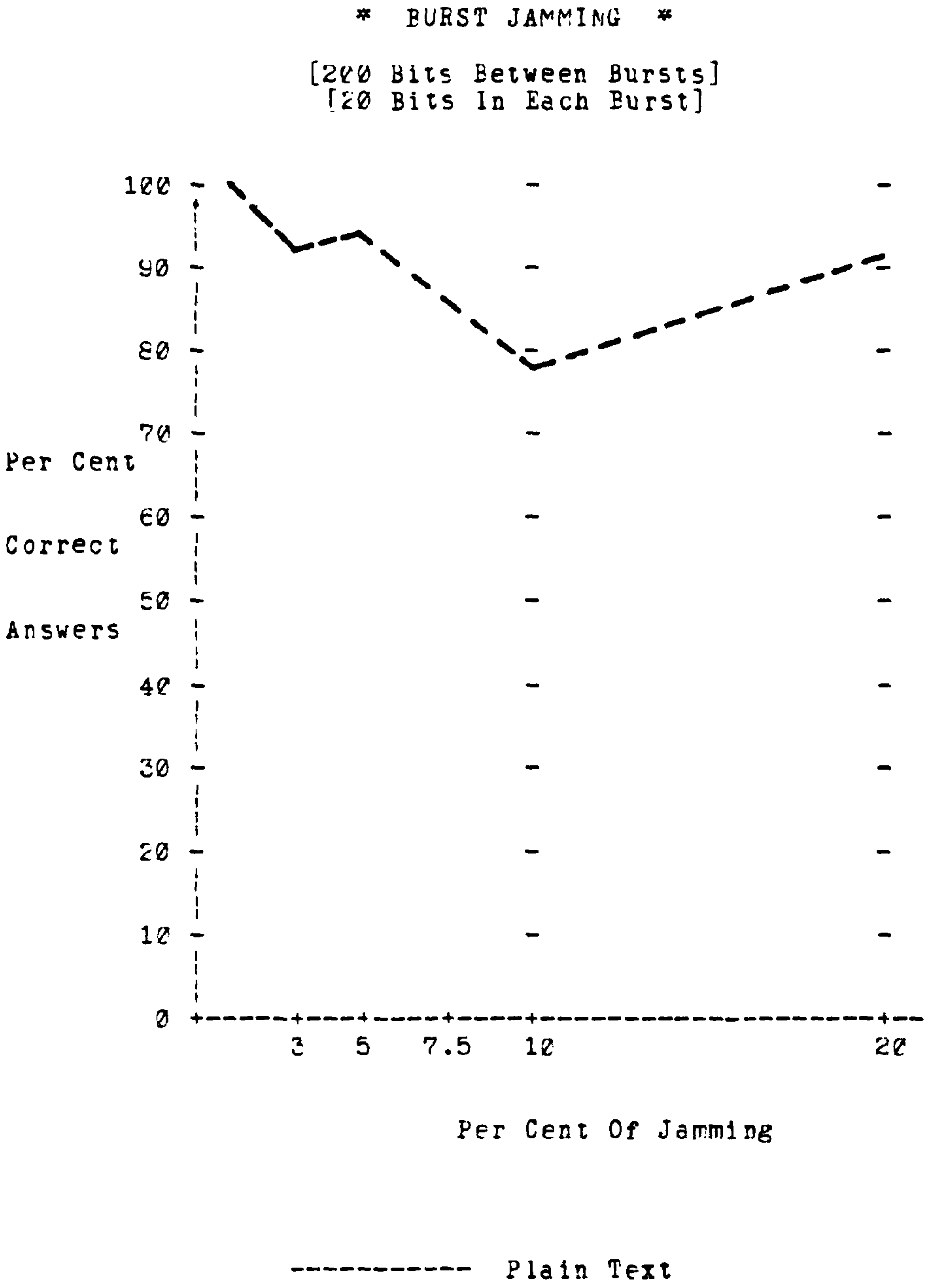



Figure 16. PLOT OF BURST JAMMING RESULTS (PILOT TRIALS)

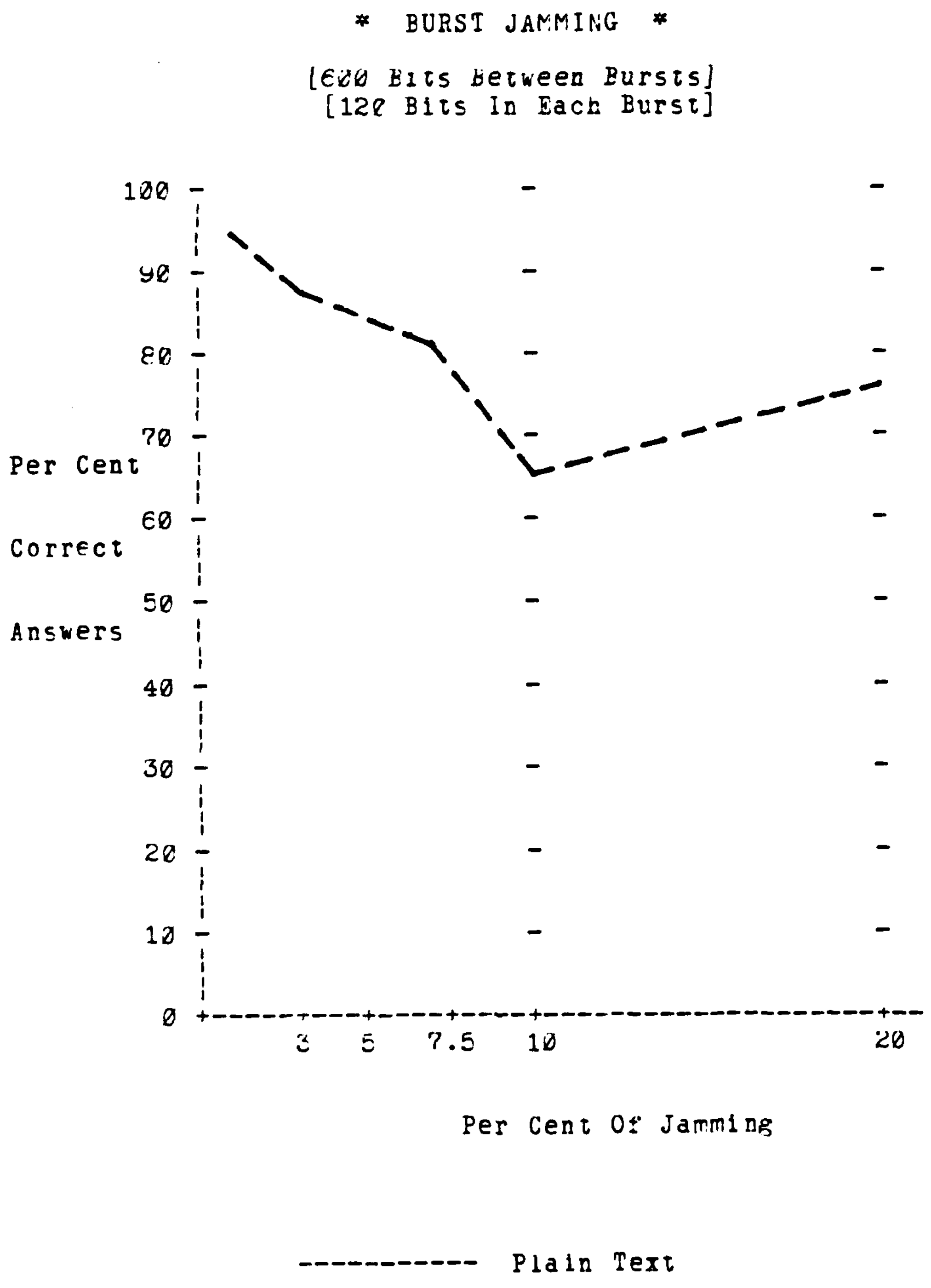



Figure 16. (CONTINUED)

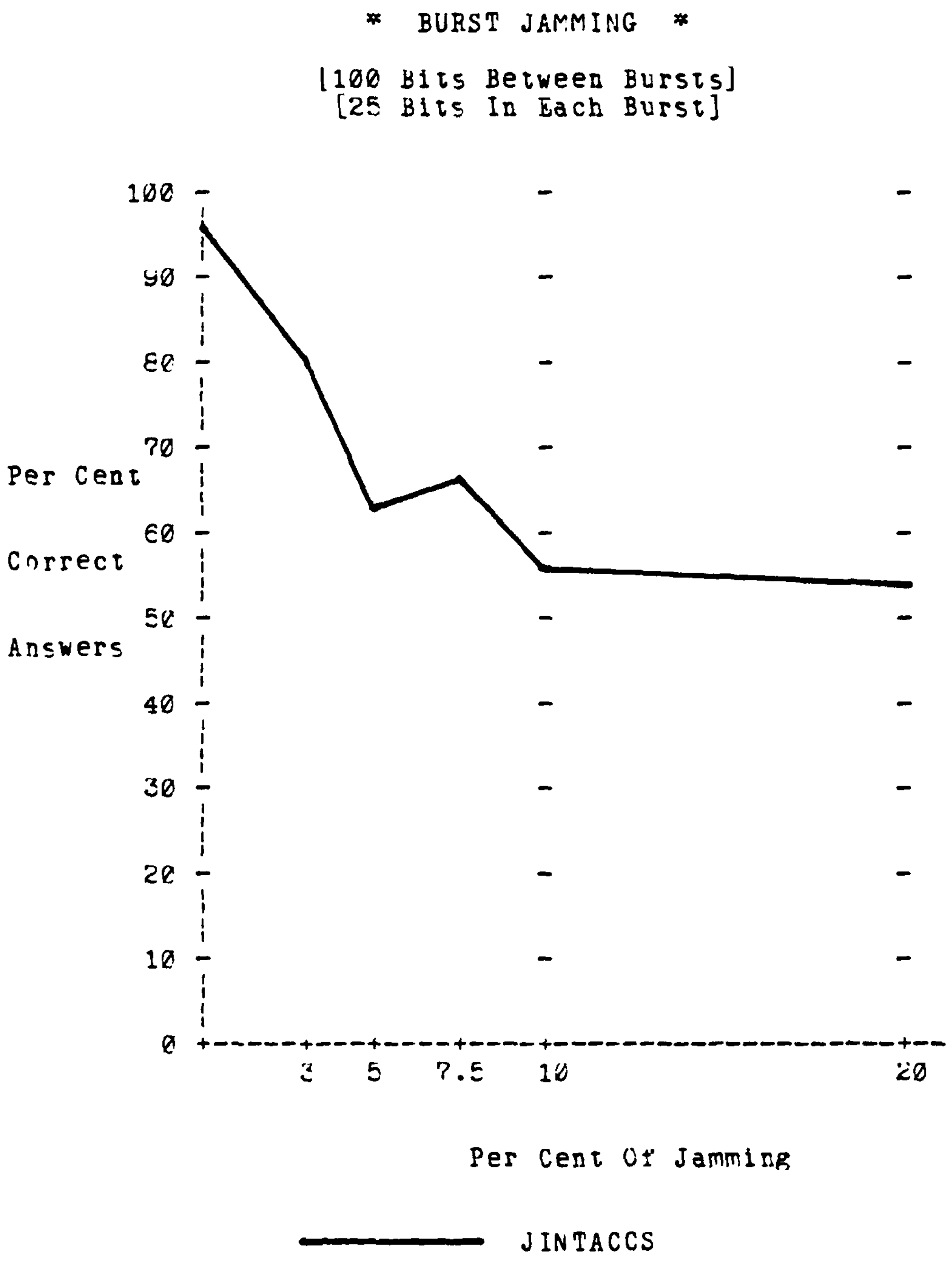



Figure 17. PLOT OF BURST JAMMING RESULTS (FIRST PART)

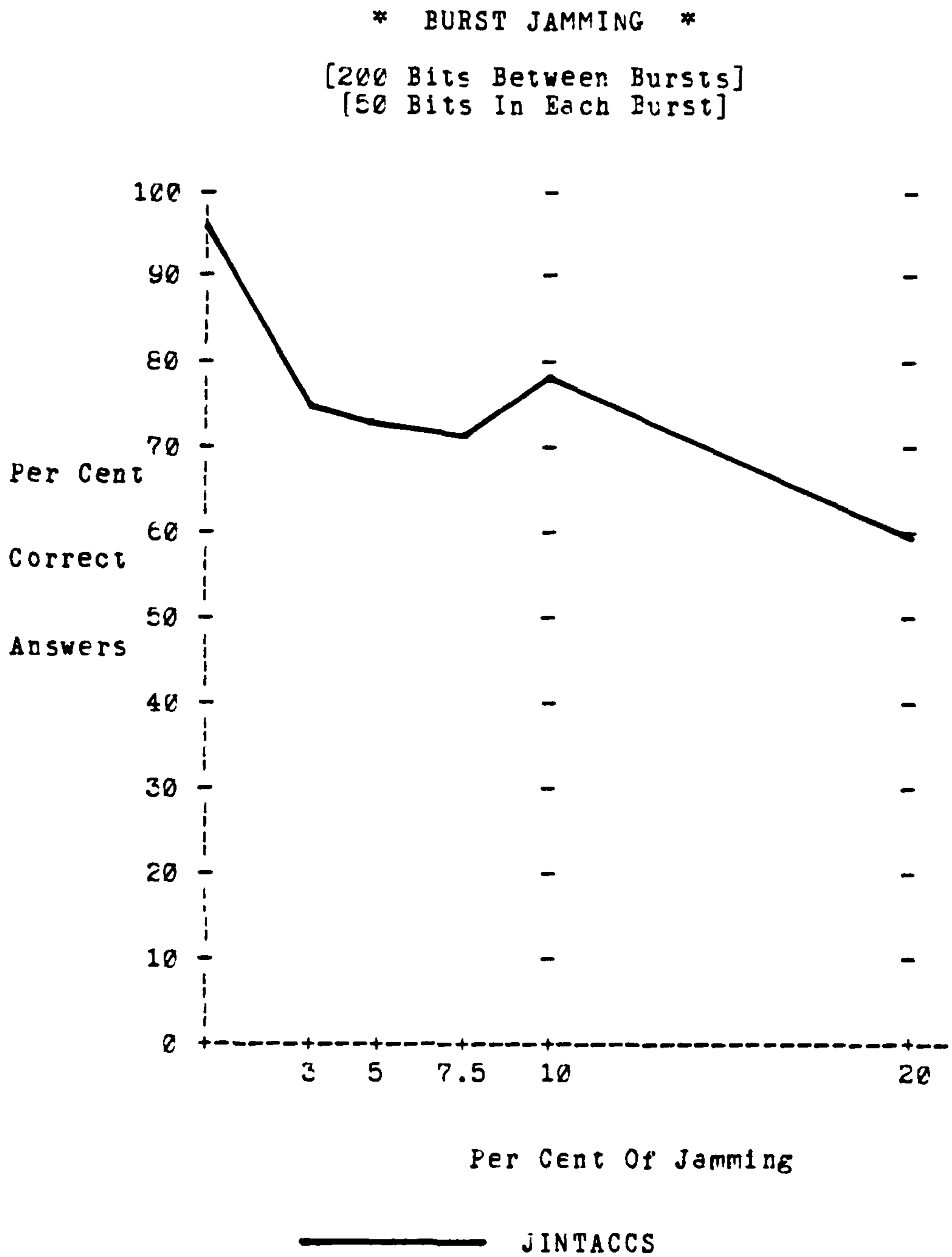



Figure 17. (CONTINUED)

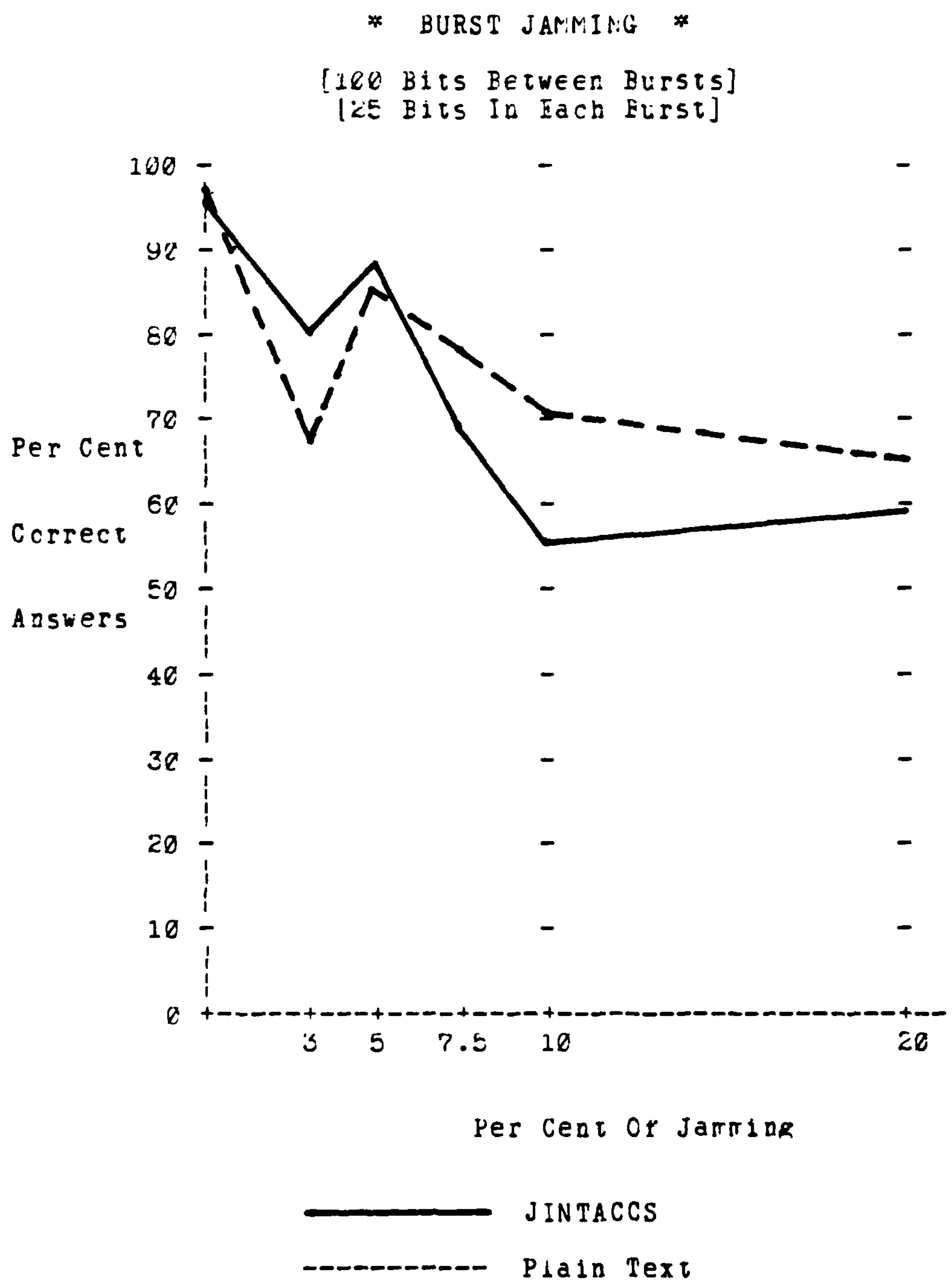



Figure 18. PLOT OF BURST JAMMING RESULTS (SECOND PART)

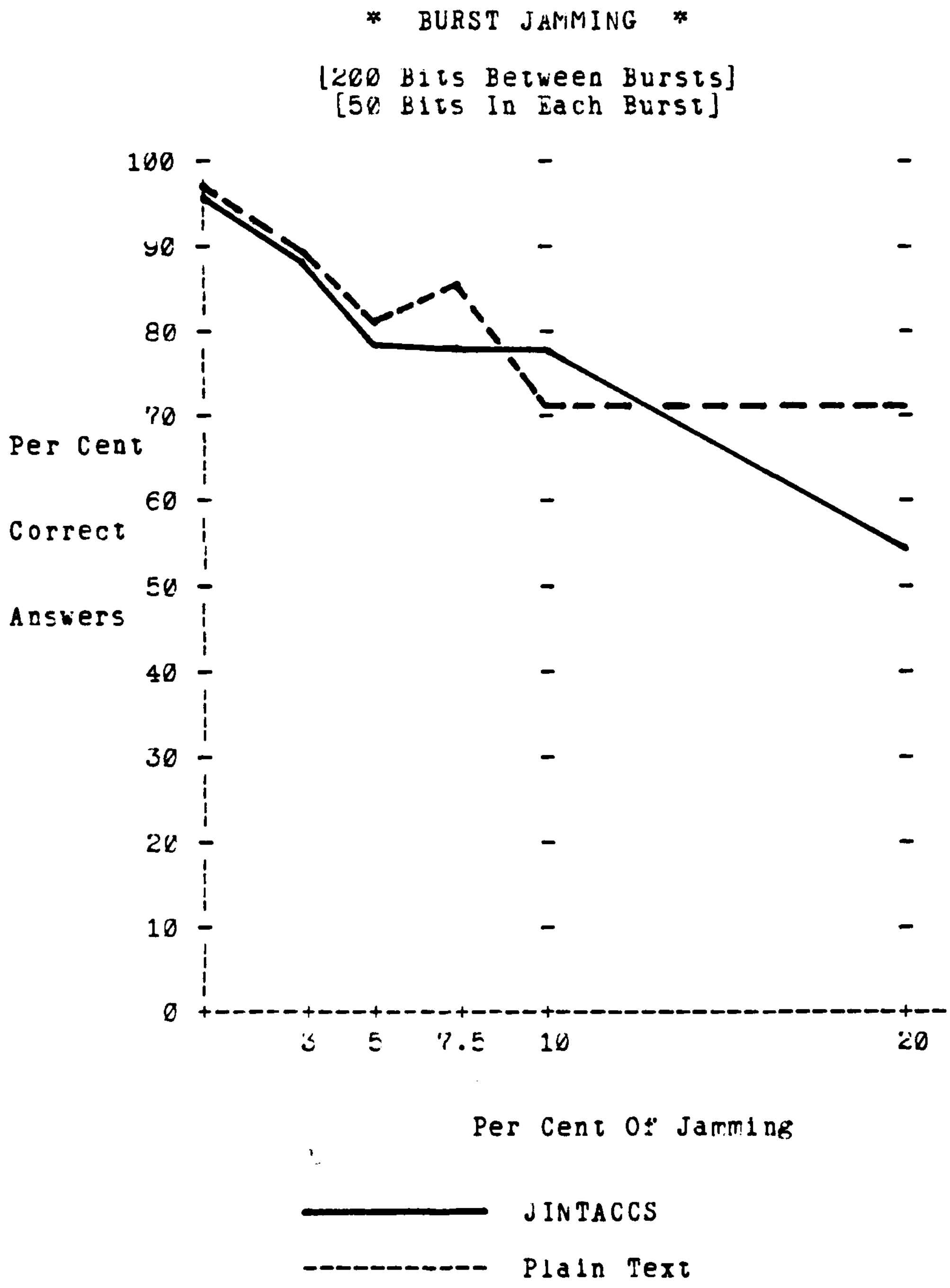



Figure 18. (CONTINUED)

DIFFERENCE CURVE (PLAIN TEXT - JINTACCS)

* BURST JAMMING *
[100 Bits Between Bursts]
[25 Bits In Each Burst]

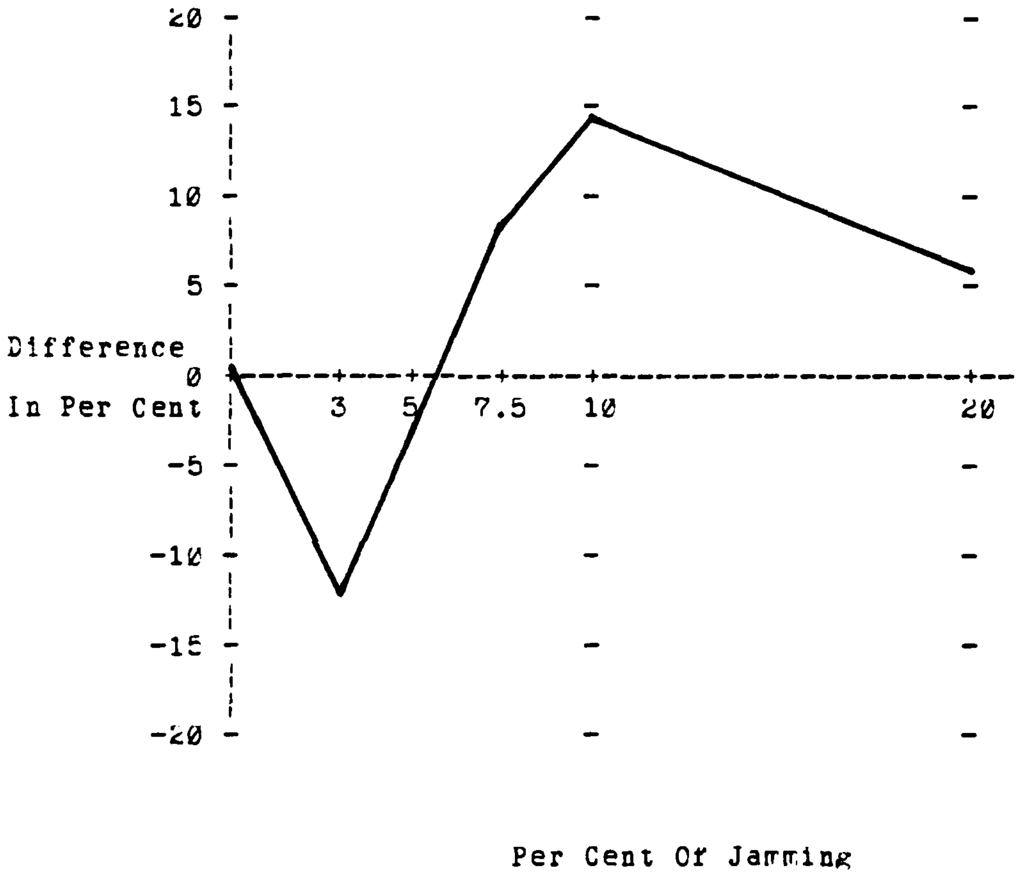



Figure 19. PLOT OF BURST DIFERENCE CURVE (SECOND PART)

DIFFERENCE CURVE {PLAIN TEXT - JINTACCS}

* BURST JAMMING *
[200 Bits Between Bursts]
[50 Bits In Each Burst]

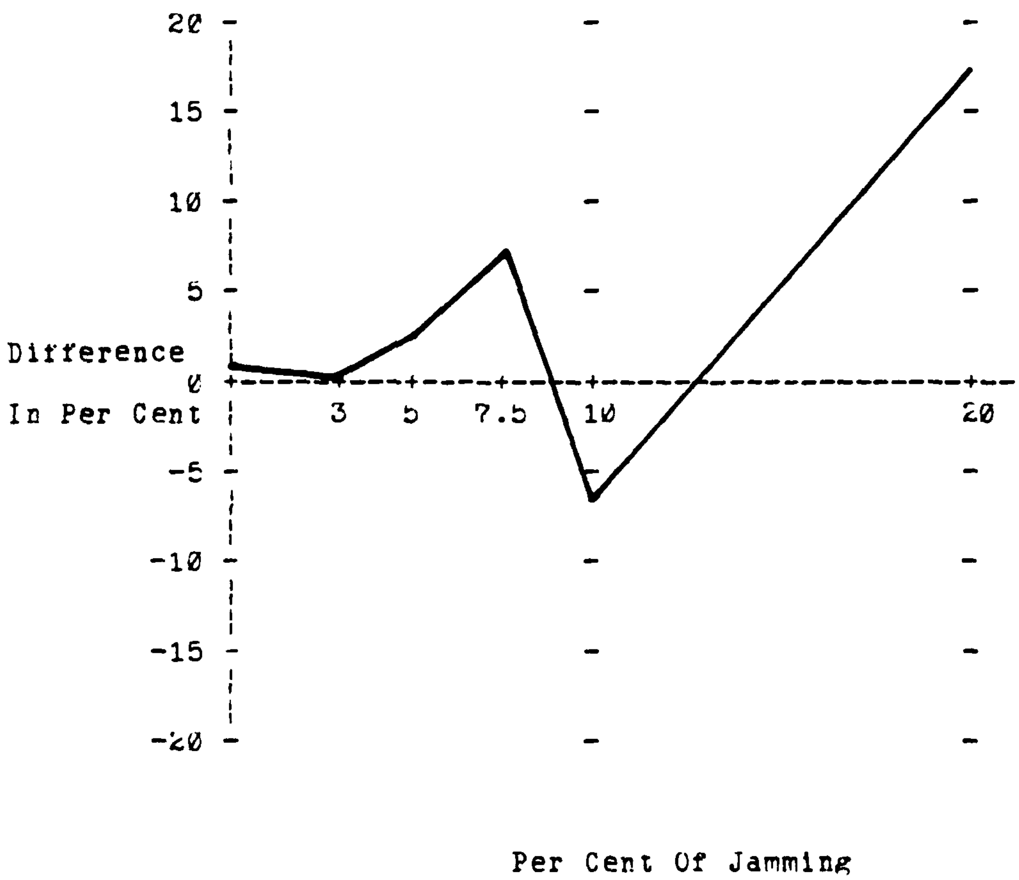



Figure 19. (CONTINUED)

more like what we expected to see. Note also that the difference curves in this case are not at all similar to each other and they do differ from the continuous jamming results curve shown in Figure 14. As the size of the burst increases and the number of bits between bursts decrease, one would expect the burst results to approach that of the continuous results.

5. Results For Subject Attitudes

The subjective questionnaires given after sub-experiment 2 and sub-experiment 3 at Langley AFB were scored and an average computed for each question. These averages along with the questions are shown in Appendix I. A shift in attitudes in almost all questions was noted and the shift was from favoring plain text messages to being either neutral or favoring JINTACCS messages. It is apparent that the time the subjects spent between sub-experiments training on the JINTACCS formats tended to build their confidence in the JINTACCS format.

## III. CONCLUSIONS

This thesis sought to determine if there was any significant difference in understandability between the JINTACCS message formats and plain text messages when an equal amount of jamming is applied to both message types. It also sought to estimate the understandability curves for each message type for a range of levels of jamming for two types of jamming. A computer program was written to simulate the effect of continuous and burst jamming, and experiments were conducted for this research.

The comparison of JINTACCS to plain text for understandability revealed no statistically significant differences. Although the plain text scores were generally higher than the JINTACCS scores in the first comparison test, the differences were not large enough to be significant with the size of the samples that we had. The scores in the second comparison test after the subjects had received more training with JINTACCS showed even less differences in the understandability of plain text messages and JINTACCS messages. The added training and familiarity with JINTACCS before the second comparison test seemed to explain the smaller differences.

The understandability curves that resulted for both continuous and burst jamming conform generally to what one would expect. The curves were similar in appearance to each

other. The experiments revealed that at 3.0% or more continuous jamming at the bit level, about half the understandability or intelligibility of a message is lost. So it appears that only a moderate amount of jamming can cause a devastating effect on our ability to communicate critical information in written messages.

Apparently little has been published on the understandability or intelligibility of written communications. Several sources were found that cited verbal intelligbility tests, and there is even a military standard of intelligibility criteria for voice communications systems [Ref. 27]. But no standards were cited for written or message communications. This seems inconsistent with our high reliance on written message communications in today's military environment.

In conclusion, it appears that messages transmitted using the JINTACCS message formats are indeed no worse nor better than plain text messages with respect to jamming survivability. The ability of military personnel to rapidly adapt to the JINTACCS message standards was amply demonstrated during the first comparison test. The majority of the test subjects had received only one and a half days of training on the JAMPS computer system. This speaks well of its 'user friendly' design. Their JINTACCS scores improved after further training but there was still no statistical difference in the percent of understandability when compared to plain text messages. Since the experiment

was conducted using the JINTACCS automated message processing system, these conclusions should not be generalized to the manual method of using the JINTACCS documentation. The questionnaires that were given to the test subjects after the first and second experiments showed a general positive shift in attitudes from favoring plain text messages to being either neutral or favoring the JINTACCS messages.

## IV. RECOMMENDATIONS FOR FURTHER RESEARCH

There are several other areas that lend themselves to follow-on research. One would be to conduct the same experiment using the manual mode of JINTACCS documentation rather than JAMPS. This would verify whether there are any differences in the percent of understandability between JINTACCS and plain text messages using the manual mode of processing JINTACCS messages. Another area that should be researched is the possibility of 'compressing' JINTACCS messages using the JAMPS system. Since the formats are standardized, the formatting information would appear on the operator's terminal screen but would not be transmitted. Only the message type plus some method of separating the data need be transmitted in order to reconstruct the message at the distant end. This would reduce the length of transmission time and thus should allow more messages to be transmitted in the same time period. A third area that could be researched would be to analyze the corrections that the subjects made or identified in each message during the understandability tests. The data were collected during the experiments reported in this thesis, but they were not analyzed. These corrections could be compared to the total number of characters that were garbled to form another comparison of the JINTACCS results to the plain text results.

One final suggestion would be to research possible specific equipment jamming threats and to repeat the experiment using those jamming parameters.

# APPENDIX A

## COMPUTER PROGRAM TO SIMULATE JAMMING

```
c     This program simulates continuous or burst electronic jamming
c     on a message file.  It translates each character in the file
c     into an eight bit code, garbles each bit based on a probability
c     of jamming specified by the user, retranslates the bits into
c     whatever characters they have now become, and prints out
c     the 'jammed' file.  More than one message can be processed
c     in a file.  Simply place a $ in the first space on the line
c     separating the last line of one message and the beginning line
c     of the next message.

      integer table(80,9), temp(9)
      integer answer, line(80), i, j, k, start, one
      integer endlin, bbcnt, bincnt, load(567)
      integer char, num, letter, bit, betwb, burlen
      integer abit, count, endbit, itemp(640)
      real jprob, random
      common table
      integer*4 i1,i2

c     Input file "2" contains the messsages, one line of 79 characters
c     per record
c     Input file "3" contains the character translation table.  Each
c     record is made up of the character and 8 characters representing
c     the characters 8 bit binary code.  This file contains 63 records,
c     one for each of the 63 allowable characters.
```

```
c     Build translation table of 63 characters and associated bits, read
c     in one charcter and its eight bit binary code at a time.
c     The table is in file for003.dat for this program.

      do 8 char=1,63
          read (3,117)  (table(char,bit), bit=1,9)
    8 continue

      one = '1'

c     i1 and i2 are used to initialize random number generator
c     called ran(i,i)

      i1 = secnds(0.0)
      i2 = i1

c     Obtain type of jamming: c = continuous, b = burst

   10 write (6,200)
      read (5,100)  answer

c     Test for burst jamming
      if (answer.eq.'b')  go to 70

c     Test for continuous jamming
      if (answer.eq.'c')  go to 20

c     Test for stop
      if (answer.eq.'s')  go to 190

c     Error message
      write (6,220)
      go to 10
```

```
c     CONTINUOUS JAMMING SECTION

c     Obtain probability of jamming or P(J)
  20  write (6,205)
      read (5,105)  jprob

c     Go to top of screen or page
  23  write (6,112)

c     Read one line of message and store into line array
  25  read(2,110,end=190)  (line(char), char=1,79)

      if (line(1).eq.'$') go to 23
c     The '$' indicates the end of a message, go to top of screen and
c     read next line.

c     Find the first non-space character at the end of the line.
c     The position of the last character, between 1 and 80 , is
c     assigned to the value of endlin.
      j = 80
      do 30 i=1,79
          j = j - 1
          if ( line(j).eq.' ' )  go to 30
              endlin = j
              go to 35
  30  continue

  35  continue
```

```
c     For each character in the line, go through the jamming algorithm.
      do 55 char=1,endlin

c         Subroutine find returns the entry number of the character
c         in the character translation table.
          call find(line(char),num)

c         Move 8 bit binary code for character into temp array
          do 40 bit=2,9
              temp(bit) = table(num,bit)
 40       continue

c         For each bit, see if it should be jammed
          do 50 bit=2,9
c             Obtain random number between 0 and 1, convert to
c             real number between 0.0 and 100.0
              random =  ran(i1,i2) * 100.0
c             Test if random number greater than jamming probability.
c             If true, no jamming; if false, reverse bit.
              if (random.gt.jprob)  go to 50
              if (temp(bit).eq.'1')  go to 45
                temp(bit) = '1'
                go to 50
 45           temp(bit) = '0'
 50       continue
```

```
c          Use subroutine transl to translate jammed bits into
c          corresponding character
           call transl(temp,letter)

c          Put character back into line
           line(char) = table(letter,1)

   55  continue

c      write jammed line
       write (6,111)  (line(char), char=1,endlin)

c      Go to read and get next message line
       go to 25

c      END OF CONTINUOUS JAMMING SECTION
```

```
c     BURST JAMMING SECTION

  70  write (6,210)
c     Obtain number of bits between bursts
      read (5,115)  betwb
      write (6,215)
c     Obtain the burst length (number of bits to be jammed within burst)
      read (5,115)  burlen
      write (6,205)
c     Obtain the probability of jamming
      read (5,105)  jprob

      write (6,116) betwb,burlen,jprob

c     Between burst counter initialized to zero
  73  bbcnt = 0
c     Bits in burst counter set to zero
      bincnt = 0
c     Switch to show first time through procedure
      start = '1'
      write (6,112)

c     Read one line of the message
  75  read (2,110,end=190)  (line(char), char=1,79)

      if (line(1).eq.'$') go to 73
c     The '$' indicates the end of a message, go to top of screen and
c     read next line.
```

```
c     Find the first non-space character at the end of the line.
c     The position of the last character, between 1 and 80 , is
c     assigned to the value of endlin.
      do 80 i=1,79
          j = 80 - i
          if (line(j).eq.' ')  go to 80
              endlin = j
              go to 85
   80 continue

   85 continue

      bit = 1
c     Process each character in the line
      do 95 char=1,endlin
c         Subroutine find returns index into table for character
          call find(line(char),num)

          do 90 abit=2,9
c             Move bit representation into work area
              itemp(bit) = table(num,abit)
c             Count bits
              bit = bit + 1
   90     continue

   95 continue

c     Compute last bit in line (8 bits per character)
      endbit = endlin * 8
```

```
c     The first time through, find random bit on which to begin bursting.
      if ( start.ne.one )  go to 145

         bbcnt = int( ran(i1,i2) * float(betwb) )
c        Set switch to show 'not start'
         start = '3'

 145  continue

c     Process each bit in line
      do 170 bit=1,endbit

c          Increment between burst counter
           bbcnt = bbcnt + 1
c          Test if between burst count greater than between burst limit
           if (bbcnt.gt.betwb)  go to 150
           go to 170

 150       continue
```

```
c          In Burst Processing
c          Increment burst counter
           bincnt = bincnt + 1
c          Test if burst count greater than number of bits to be burst.
           if (bincnt.gt.burlen)   go to 165

c              Obtain random number between 0 and 1, convert to
c              real number between 0.0 and 100.0
               random =  ran(i1,i2) * 100.0
c              Test if random number greater than jamming probability.
c              If true, no jamming; if false, reverse bit.
               if (random.gt.jprob)  go to 170
c              Reverse bit, "1" becomes "0" or "0" becomes "1".
               if (ltemp(bit).eq.'1')  go to 155
                 ltemp(bit) = '1'
                 go to 170
 155           ltemp(bit) = '0'
               go to 170
c          End of jamming; reinitialize bits in burst counter and
c          bits between burst counter.

 165       bincnt = 0
           bbcnt = 1

 170   continue
```

```
c     Move bits back into hold area for each character.
      bit = 1
      do 180 char=1,endlin
         do 175 j=2,9
            temp(j) = ltemp(bit)
            bit = bit + 1
 175     continue

c        Use subroutine transl to translate jammed bits into
c        corresponding character
         call transl(temp,letter)
c        Move each character back into line.
         line(char) = table(letter,1)

 180  continue

c     Write out the jammed line
      write (6,111)  (line(char), char=1,endlin)

c     Go back and read next message line
      go to 75

c     END OF BURST JAMMING SECTION


 190  continue
```

```
100  format (a1)
105  format (f7.3)
110  format (80a1)
111  format ('0',79a1)
112  format ('1',//)
115  format (i4)
116  format (1x,'betwb ',i5,'    burlen ',i5,'    jprob ',f7.3)
117  format (1x,a1,3x,a1,3x,a1,3x,a1,3x,a1,3x,a1,3x,a1,3x,a1,3x,a1)

200  format (1x, 'Specify continuous (c) or burst (b) jamming
    * or (s) for stop',/)
205  format (1x, 'Specify probability of jamming',/)
210  format (1x, 'Specify bits between bursts',/)
215  format (1x, 'Specify bit length of burst',/)
220  format (1x, 'Invalid response - try again',/)

     stop
     end
```

```
      subroutine find(letter, number)

c     This subroutine searches the array table, which contains the bit
c     composition of all the characters, to find out what number
c     between 1 and 80 the character is.  The input is the character
c     the program wants to find, called letter here.  The output is
c     the integer number of which character the letter is, or if the
c     subroutine cannot find the character, it says it is character
c     number 32 or a 'space'.  Since there are 80 characters in the
c     array table, the purpose of this subroutine is simply to find
c     what row the character is in.

      integer table(80,9)
      integer letter, number, num
      common table

      do 10 num=1,73

         if (letter.ne.table(num,1))  go to 10
         number = num
         return

   10 continue

      number = 32
      return

      end
```

```
      subroutine transl(input, letter)

c     This subroutine translates input eight bits into whatever character
c     they match in the array table, and returns the index to the table
c     for the matching entry.  If no match is found index 32 is returned
c     to indicate a space.

      integer table(80,9)
      integer letter,input(9)
      common table

c     Perform for each entry in the table.
      do 20 i=1,73

c        Test each bit in table entry against input
         do 10 j=2,9

            if (input(j).ne.table(i,j))  go to 20

 10      continue

c        Match found, return row number of matching entry.
         letter = i
         return

 20   continue

c     Match not found, return row number for "space".
      letter = 32
      return

      end
```

# APPENDIX B

## DATA FILE FOR CHARACTER CODES

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| A | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| B | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| C | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| D | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| E | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| F | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| G | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| H | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| I | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| J | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| K | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| L | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| M | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| N | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| O | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| P | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Q | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 |
| R | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| S | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| T | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| U | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| V | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 |
| W | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| X | Ø | 1 | Ø | 1 | 1 | Ø | Ø | Ø |
| Y | Ø | 1 | Ø | 1 | 1 | Ø | Ø | 1 |
| Z | Ø | 1 | Ø | 1 | 1 | Ø | 1 | Ø |
| [ | Ø | 1 | Ø | 1 | 1 | Ø | 1 | 1 |
| | Ø | 1 | Ø | 1 | 1 | 1 | Ø | Ø |
| ] | Ø | 1 | Ø | 1 | 1 | 1 | Ø | 1 |
| ^ | Ø | 1 | Ø | 1 | 1 | 1 | 1 | Ø |
| @ | Ø | 1 | Ø | Ø | Ø | Ø | Ø | Ø |
| | Ø | Ø | 1 | Ø | Ø | Ø | Ø | Ø |
| ! | Ø | Ø | 1 | Ø | Ø | Ø | Ø | 1 |
| " | Ø | Ø | 1 | Ø | Ø | Ø | 1 | Ø |
| # | Ø | Ø | 1 | Ø | Ø | Ø | 1 | 1 |
| $ | Ø | Ø | 1 | Ø | Ø | 1 | Ø | Ø |
| % | Ø | Ø | 1 | Ø | Ø | 1 | Ø | 1 |
| & | Ø | Ø | 1 | Ø | Ø | 1 | 1 | Ø |
| ( | Ø | Ø | 1 | Ø | 1 | Ø | Ø | Ø |
| ) | Ø | Ø | 1 | Ø | 1 | Ø | Ø | 1 |
| * | Ø | Ø | 1 | Ø | 1 | Ø | 1 | Ø |
| + | Ø | Ø | 1 | Ø | 1 | Ø | 1 | 1 |
| , | Ø | Ø | 1 | Ø | 1 | 1 | Ø | Ø |
| - | Ø | Ø | 1 | Ø | 1 | 1 | Ø | 1 |
| / | Ø | Ø | 1 | Ø | 1 | 1 | 1 | 1 |
| Ø | Ø | Ø | 1 | 1 | Ø | Ø | Ø | Ø |
| 1 | Ø | Ø | 1 | 1 | Ø | Ø | Ø | 1 |
| 2 | Ø | Ø | 1 | 1 | Ø | Ø | 1 | Ø |
| 3 | Ø | Ø | 1 | 1 | Ø | Ø | 1 | 1 |

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THE SUSCEPTIBILITY OF JINTACCS MESSAGES TO JAMMING.(U)
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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 5 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 6 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 7 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 8 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 9 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| : | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| ; | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| < | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| = | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| > | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| ? | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |

# APPENDIX C

## COMPUTER PROGRAM SAMPLE INPUT FILE

### SAMPLE JINTACCS AIRLIFT REQUEST MESSAGE

```
FROM/ABCC1/RUJIAAE/ABCCC LANGLEY AFB VA/U/O/O/152055Z OCT 81//
TO/JTF-JTB1/RUJICAD/JTF JTB FT MONMOUTH NJ//
TO AF-TACC1/RUJIAAB/AF TACC LANGLEY AFB VA//
UNCLAS
OPER/PTU CERTIFICATION//
MSGID/ALREQ/ABCC1/1015001//
CANX/ALREQ/ABCC1/141200Z/OCT/1014001//
AMPN/AMENDMENT 3//
LIFTREQ/-/REQNO:5G107/PRY:1/TALTYP:AIRLD/NOTPAC:5C130//
6LOAD
/DE ONLOC  ONTIME   QTY  LDTYP  - -  OFFLOC OFFTIME  QTY
/01 UDTHAN 161300Z  245  PASSENGERS  KORTAB 161400Z  230
/02 UDTHAN 161300Z   40  AMMO CRATES KORTAB 161400Z   40
//
9LOAD
/DE CARGOWT CARGOSZ LGTH WDTH HEIGHT  HZD SD NEW    CC
/02   10TON  30CUF  3FT  2FT  5FT     A - N  -  1TON//
LANDPT/UDTHAN/PTNM:UDORN AIR BASE:261030N1073530E//
CONTACT/UDTHAN/-/CNTNAME:CAPT MORRISON/8048502072/LSSTAT:COLD
/TWO RAMPS.//
HEADING/SPECIAL INSTRUCTIONS//
AMPN/CONTACT BOOMER ON FREQ 245.5 PRIOR TO LANDING AT UDTHAN.//
AKNLDG/N//
RMKS/CODE 6 PASSENGER REQUIRES TLC AT DESTINATION.//
```

## SAMPLE PLAIN TEXT AIRLIFT REQUEST MESSAGE

```
ROUTINE
ZNR UUUCC
R 212237Z OCT 81
FROM ABCC1  LANGLEY AFB VA//
TO  RUJICAD/JTF-JTB1  FT MONMOUTH NJ//
RUJIAAB/AF-TACC1  LANGLEY AFB VA//
BT
UNCLAS
OPERATION: PTU CERTIFICATION
THIS IS THE FIRST ALREQ SENT OUT BY OUR UNIT TODAY. THIS MESSAGE CANCELS OUR
ALREQ #1, AMENDMENT 3, SENT YESTERDAY.  THIS MESSAGE REQUESTS AIRLIFT
(REQUEST NUMBER 5G107, PRIORITY: 2) USING FIVE C-130 AIRCRAFT.  THE AIRCRAFT
WILL ONLOAD 245 PASSENGERS AT UDTHAN AT 1300Z TOMORROW.  CARGO WILL ALSO BE
ONLOADED AT THE SAME POINT (10 TONS, 30 CUBIC FEET, WITH A LENGTH OF THREE
FEET, WIDTH OF TWO FEET, AND HEIGHT OF FIVE FEET).  THE CARGO IS AMMUNITION
(HAZARD TYPE "A").  "SINGLE DAGGER" IS NOT REQUIRED. THE NET EXPLOSIVE WEIGHT
OF THE AMMO IS 1 TON.  PASSENGERS AND CARGO WILL BE TRANSPORTED TO KORTAB, TO
ARRIVE AT 1400Z ON THE SAME DAY.  PASSENGERS AND CARGO WILL THEN BE OFFLOADED
AT KORTAB.  THE C-130'S MUST CONTACT BOOMER ON FREQUENCY 245.5, PRIOR TO
LANDING AT UDTHAN (261030N  1073630E).  NO ENEMY ACTIVITY HAS BEEN NOTED AT
UDTHAN.  SPECIAL EQUIPMENT NEEDED AT UDTHAN INCLUDES TWO RAMPS.
PHONE CAPT MORRISON (804-850-2072) ON ARRIVAL AT UDTHAN.  THE MESSAGE YOU
SEND SHOULD INCLUDE THE FOLLOWING SPECIAL INSTRUCTIONS:  "CODE 6 PASSENGER
REQUIRES TLC AT DESTINATION."
BT
```

APPENDIX D

COMPUTER PROGRAM SAMPLE OUTPUT FILE (CONTINUOUS JAMMING)

JINTACCS MESSAGE WITH CONTINUOUS JAMMING AT THE 1.0% LEVEL

```
FROM/ABCC1/RUJIAAE/ABCCC LANGLEY CFB VA/U/O/O 1520 5Z OCT 91//
TO/JTF-JTE1/R JISAD/JT  JTB F  MOAMOU H NJ//
TO AF-TACC1/RUJIAAB/AF TACC LANFLEY AFB VA//
UNCLAS
OPER/PTT CERT FICATION//
MSGID?ALRES/ABCC1/1015001/.
CANX/ALRUQ/ABCC1/141200Z/OCT/1014001//
AMPN/AMFNDMFNT 3//
LIFTREQ/-/REQNO:5G107/@RY:5/TALTYP:AMRLD/NOTPA :5C130//
6LOAD
/DE OOLOC  ONTIME  0QTY $LDTYP  - -  OFFLOC OFFTIME  QTY
/01 UDT@AN 161300Z  245  PQSSENGERS  KORTAC 161>00Z  230
/02  CTHAN 161  0Z    40  AM O CRATES KORTAB 161400    40
//
9\OAD
/DE CARGOWT CARG SZ LETH WDTH HEIGHT  HZD SD NEW    SC
/02   10TON  38CUF  3FT  2FT  5FT     AI-    -  1TON//
LANDPD/UDTHAL/PTNM:EDORJ AIR BASE:26103 N11´3530E /
CONTAC /UDTHEN/-/CNTNAME*CAPP MORRISCN/824:502072/LS TAT:COLD
/TWC RAMPS.//
HEADING/SPECIAL INRTRUCTIONS//
AMPN/ ONTACT(BOOMA  O  FREQ 245.5 PRIOR T  LAN@ING$AT UDTHAN, /
AKNLDG/N//
RMKS/CODE 6 PASSENGER REQUIRES TLC AT DESPINATION.//
```

PLAIN TEXT MESSAGE WITH CONTINUOUS JAMMING AT THE 1.0% LEVEL

```
ROUTINE
ZNR UUUCC
R 2 2237Z 0 T 81
FROM A CC1  LANGLEY AFB VA//
 O( RUJ CAD JTF-JTB1  FT MONMOUDH NJ?/
RUJIAAB/ F-TACC1( LANGLEY! FB VA//
BT
]N LAS
O@ERATION: PTU CERTIFI[ATION
THIS  SØTHE FIRST A REQ S NT OUT BY OUR UNIT TODAQ.ØTHISØ]ESSAGE CA CELS OUR
AIREQ #1  AMENDMENT 3, SMNT YASTERDAY.  THIS MESSAGE REQU STS PIRL FT
(REQUEST N]MBER 5G107, PRIORITY: 2)ØUSING FIVE C-13Ø AIRCRAFT.  TLE AIRCRAFT
GILL ONLOAD 245 RASSENGERS @T UDTHAN AT 13ØØZ TOMORROW.  CARGM WILL ALSO BE
ONLOADGD AT THE SAME POINT (1Ø TONS, 3Ø CUBIC FEET, WITH A LENG\H OF THREE
FEET, WADTHIOF TWO FEEP,  ND$HEIGHT OF FIVE FEET).  THE CAVGO IS AMMUNITION
)HAZAR  TYPE "C").  "SINGLE DAGGER" IS NOT REQUIRED. THE NET EXPLOSIV  WEIGH
OF TJE AMMO IS 1 T F.  PASSENGERS  ND CARGO WILL BE TRAN[PORTED TO KORTAB, TO
 RR  E AT 94ØØZ ON THE RQME DAY.  PAS ENGERS AND CARGO WILL THEN BE OBIL ADED
AT KORTAB.  THE C-13Ø'S  UST BONTACT BOOMER ON FRIQU NCY 245.5, PRIOR TO
LANDING AT UDTHAN (261Ø3ØJ  1Ø73634E).  NO ENEMY"ACTIVITY HAS BEEN NOTED QT
UDTHAL.  SPECIAL EQUIPMENT NEEDEE AT TDTHAN INCLUDES TWO RAMPS.
PHONE CAPT MORRISON (8 4 85Ø-2Ø72) ON ARRIVAL AT UDTHAN.  THE M SSAC  YOU
SEND SPKULD INCLUDE THE FOLMOW NG SPECIAL ILSTRUCTIONS:  "CODE 6  ASSE GER
REQUIRES TLC AT DESTINATION "
BT
```

## APPENDIX E

### COMPUTER PROGRAM SAMPLE OUTPUT FILE (BURST JAMMING)

JINTACCS MESSAGE WITH BURST JAMMING
(100 BITS BETWEEN EACH BURST, 25 BITS IN THE BURST, AND 10.0% JAMMING)

```
FROM/ABCCC'RUJIAAE/ABCCC HANGLEY AFB VA/U?O/O/152055Z OC  91//
TO/JTF-JTF /RUJICAD/JTF JTB1FT MONMOUTH NO/?
TO AF-TACC1/RQBIAAB/AF TACC  G GLEY AFB VA//
  CLAS
OPER/PTU G  TIFICATION//
M GHD/ALREQ/ABCC1 3 15001//
CANX/   EQ/ABCC1/14120 Z/OCT/1014001/
  PN/AMENDMENT S?/
LIFTREQ/-/REQ^O:5G10?/PRY:1/TALTYP:AIRLD/NO PAC:5C130//
6LOAD
 DE ONLOC  ONTYMG   QTY  LDTYP  = -  OFFLOC ODFTIME  QTY
/01 UG HAN 1613002  647  PASSENGERS (KORTAB 161400Z  2 0
/02 UDTHAN 1613002   40  AMM 0CRATES KORTAB  214002   40
//
1LG D
/DE CARGOWT CORGOSZ LGTH WOTH HEIGHT  HZD SD  FW    CC
/02   30TON  30CUF "3    2FT  5FT     A - N  -  1TMN ?
LANDPT/UDTHAO+RTNM:UDORN AIR BISE:261030N1073  0E//
CONTACT/]DTHAN/-/CNTNAME:SAPT MORRISON/8 58502072/LSSTAT:COLD
/TWO RAMPS ;
HEADING/SPECIA  INSTRUCTIONS
EMPN/CONTACT BMOMER ON FREQ 247*5 PRIOR TO LA DING AT UDTHAN./=
AKNLDG/N//
RMKC'C DE 6 PASSENG P(REQUIRES TLC"AT0DESTINATION. ,
```

PLAIN TEXT MESSAGE WITH BURST JAMMING
(100 BITS BETWEEN EACH BURST, 25 BITS IN THE BURST, AND 10.0% JAMMING)

```
ROUTINE
ZNR UUUCC
R 21223    OCT 81
FROM A CC1  LANGLEY AD@0VA//
TO  RUJICAD/JTF-JTB1  FT EGNMOUTH NJ//
RT  AAB/AF-TACC1 ,DGFGLEY AFB VA//
B
UNCLAS
OPERATION  PTU CERTIFICE]ION
THIS IS THE FIRST ALREQ SEN 0OUT BY OUR UN T TODAY. THIS I SSAGE CANCELS" UR
ALREQ #1, AME DMENT 3, SENT [ WTERDAY.  THIS"MESSAGE REQUESPW@AIRLIFT
(REQUDSU NUMBER 5G107$IPRIORITY: 2) USI G FIVE C-130  IRCRAFT.  THE QIPCRAFT
WILL CNL ED 245 PASSENGERS AT UDTHAN AT 3700Z TOMORROW.! CARGO WILL ALSO BE
ONLOADED AT TIE SAME POINT  18 TONS, 30 CUN B FEET, WITH A0OGNGTH OF THRED
VE T, WIDTH OF   O FEET, AND HEI XT CF FIVE FETT).  THE CARGO  C AMMUNITION
(HEZ@RD TYPE "A").0 2SINGLE LAGGES"  S NOT REQUIRFT- THE NET EXPLMW| E WEIGHT
OF TH  AMMO IS 1 TOJ   PASSENGERS A   CARGO WILL BD  BANSPORTED TO CORTAB, TC
ARRIVE QT 1400Z ON THE$SAME DAY.  PAU  NGERS AND CAWGI(WILL THEN BE  F LOADED
AT KOR\AJ.  THE C-130' "MUST CONTACT   NMER ON FREQUE CY 245.5, PRIOJ P
LANDING AT U UHAN (261030N  3<73630E).  NO E  MY ACTIVITY HQR BEEN NOTED A\
U DHAN.  SPECIAM  QUIPMENT NEED D0AT UDTHAN INC TDES TWO RAMPS+
X ONE CAPT MORRIVON (804-850-2132) ON ARRIVAL QU UDTHAN.  THE -E SAGE YOU
SEND"R  ULD INCLUDE T   FOLLOWING SPECIAL INSTRUCTI NY:  "CODE 6 PAC UNGER
REQUIRES DL  AT DESTINAT ON."
BT
```

## APPENDIX F

### LIST OF JINTACCS AIR OPERATIONS MESSAGES

| MSG-NO | MESSAGE TITLE |
|---|---|
| F541 | Acknowledge Message [AKNLDG] |
| E710 | Air Defense Command Message [ARDEFCOM] |
| E715 | Air Defense Warning Message [AIRDEFWARN] |
| A651 | Air Employment/Allocation Plan [EMPLOYALOC] |
| A661 | Air Mission Request Status/Tasking Message [REQSTSTSK] |
| B704 | Airbase Change Report [ABCHANGE] |
| F631 | Airlift Mission Schedule [ALMSNSCD] |
| D630 | Airlift Request [ALREQ] |
| B705 | Alert Aircraft/SAM Status Report [ACSAMSTAT] |
| A770 | Alert Launch Order [ALORD] |
| A650 | Apportionment/Allotment Message [APORALOT] |
| C460 | Communications Spot Report [COMSPOT] |
| F654 | Cross-Force Mission Data Confirmation Message [CROSSCONF] |
| A653 | Cross-Force Mission Data Message [CROSSDAT] |
| F750 | Designated Area Message [DESIGAREA] |
| F751 | ECM Data Message [ECMDAT] |
| B711 | Engagement Status [ENGSTS] |
| F632 | Flight Control Information Message [FLTCONTINFO] |
| F751 | Flight Plan Message [FLTPLN] |
| F636 | Helicopter Airlift Mission Data Confirmation Message [HELOALCONF] |
| A635 | Helicopter Airlift Mission Data Message [HELCALDAT] |
| F706 | Initiate Handover Message [INITHAND] |
| D665 | Joint Air Support Request [JAIRSUPREQ] |
| B750 | Joint Inflight Report [JINFLT] |

| | |
|---|---|
| B702 | Joint Launch Report [JLNCHREP] |
| D669 | Joint SAR Request [JSARREQ] |
| C001 | Message Change Report [MSGCHANGEREP] |
| E707 | Receive Handover Message [RCVHAND] |
| F625 | Request Confirmation Message [REQCONF] |
| C482 | Search And Rescue Incident Report [SARIR] |
| C420 | Search And Rescue Situation Summary [SARSIT] |
| B703 | Significant Air Event Report [AIREVENT] |
| A652 | Sortie Allotment Message [SORTALOT] |
| A690 | Tactical Operational Data [TACOPDAT] |
| A691 | Technical Operational Data [TECHOPDAT] |
| F755 | Track Intelligence Message [TRKINTEL] |
| F752 | Track Management Message [TRKMAN] |
| F753 | Track/Point Report [TRKREP] |

# APPENDIX G

## MESSAGE PACKET INSTRUCTION SHEET

NAME: ____________________

In a tactical environment, teletype messages must often stand alone to convey the information you would like to say in person or over the telephone. The choice of message format hopefully improves your ability to communicate and to understand the written words of the message. The purpose of this exercise is to compare the JINTACCS message format to an all plain text message format to see if one format is more effective in communicating in a jamming environment than another.

There are two groups of messages, 6 JINTACCS AND 6 Plain Text, in this packet. Each group is labeled at the start. The messages in this packet have all been "garbled" by a computer model that simulates electronic jamming.

PLEASE DO THE FOLLOWING FOR EACH MESSAGE:

1. CORRECT THE GARBLED LETTERS as best you can by writing the correct letters above the bad ones for each message.

2. ANSWER THE QUESTIONS for each message to the best of your ability.

# APPENDIX H

## SUBJECT QUESTIONNAIRE

THE PURPOSE OF THIS SURVEY WAS TO DETERMINE THE SUBJECTS' ATTITUDES AND THINKING ABOUT THE JINTACCS MESSAGE FORMATS. THE TEST SUBJECTS ANSWERED EACH QUESTION BY PLACING A MARK ON THE LINE. THE AVERAGE OF THEIR RESPONSES FOR EACH QUESTION IS SHOWN BY A * FOR THE FIRST SURVEY AND A + FOR THE SECOND SURVEY. THE '--->' or '<---' SHOWS THE DIRECTION OF ANY SHIFT IN ATTITUDES FROM THE FIRST TO THE SECOND SUB-EXPERIMENTS.

1. WHICH OF THESE TWO MESSAGE FORMATS DO YOU THINK IS THE EASIER TO WRITE A MESSAGE?

```
PLAIN TEXT                  NEUTRAL                 JINTACCS
                      *         +
 <==1=========2=========3*========+=========5=========6=========7==>
                      3.1 ---> 4.0
```

2. WHICH OF THESE TWO MESSAGE FORMATS DO YOU THINK IS THE EASIER TO RECEIVE AND UNDERSTAND THE MESSAGE?

```
PLAIN TEXT                  NEUTRAL                 JINTACCS
                   *                +
 <==1=========2======*==3=========4==+======5=========6=========7==>
                  2.7 ----------> 4.3
```

3. WHICH OF THESE TWO MESSAGE FORMATS ALLOWS YOU TO SPOT CRITICAL INFORMATION FASTER?

```
PLAIN TEXT                      NEUTRAL                           JINTACCS
                                   *           +
 <==1=========2=========3========*4=========5+========6=========7==>
                                    3.9 ------> 5.1
```

4. HOW EASY OR HARD IS THE JINTACCS MESSAGE FORMAT TO LEARN?

```
EASY                            NEUTRAL                               HARD
                                 +     *
 <==1=========2=========3======+==4==*======5=========6=========7==>
                                3.7<- 4.3
```

5. HOW EASY OR DIFFICULT IS THE JINTACCS FORMAT TO TRANSLATE?

```
EASY                            NEUTRAL                               HARD
                              +           *
 <==1=========2=========3===+=====4=====*===5=========6=========7==>
                             3.4 <------ 4.6
```

6. IF YOU HAD USED ONLY THE JINTACCS FORMAT FOR THE PAST SEVERAL MONTHS, YOU WOULD HAVE NOT HAD TO REFER TO THE FORMAT MANUALS NOR THE COMPUTER TO UNDERSTAND THE MESSAGES.

```
STRONGLY DISAGREE               NEUTRAL                    STRONGLY AGREE
                         *                  +
 <==1=========2=========*=========4=======+=5=========6=========7==>
                         3.0 ------------> 4.8
```

7. WHICH OF THESE TWO MESSAGE FORMATS WOULD YOU PREFER TO USE?

```
PLAIN TEXT                             NEUTRAL                          JINTACCS
                                      *          +
<==1=========2=========3===*=====4=======+=5=========6=========7==>
                                 3.4 --------> 4.8
```

8. WHICH OF THESE TWO MESSAGE FORMATS DO YOU THINK WE SHOULD USE?

```
PLAIN TEXT                             NEUTRAL                          JINTACCS
                                         *     +
<==1=========2=========3=======*=4====+====5=========6=========7==>
                                     3.8 -->4.5
```

9. JINTACCS MESSAGE FORMATS WILL ENHANCE MISSION COORDINATION WHEN DEPLOYED
IN A TACTICAL ENVIRONMENT.

```
STRONGLY DISAGREE                      NEUTRAL                    STRONGLY AGREE
                                          + *
<==1=========2=========3=========4+=*======5=========6=========7==>
                                       4.1<4.3
```

10. WHICH FORMAT WAS EASIER TO UNDERSTAND AFTER THE MESSAGES HAD BEEN
GARBLED?

```
PLAIN TEXT                             NEUTRAL                          JINTACCS
                                    *       +
<==1=========2=========3*========+=========5=========6=========7==>
                               3.2 ---> 4.Ø
```

11. IN WHICH FORMAT WERE YOU MOST CONFIDENT OF YOUR TRANSLATION OF THE GARBLED MESSAGE?

```
PLAIN TEXT                       NEUTRAL                     JINTACCS
                         *          +
<==1=========2=========*=========+=========5=========6=========7==>
                        3.0 ----> 4.0
```

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